REPORT RESUMES

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INTERACTION OF INDIVIDUAL DIFFERENCES WITH METHODS OF PRESENTING PROGRAMED INSTRUCTIONAL MATERIALS BY TEACHING MACHINE AND COMPUTER. FINAL REPORT.

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TWO EXPERIMENTS WERE DESIGNED TO MEASURE INTERACTION EFFECTS OF INDIVIDUAL DIFFERENCES IN COLLEGE STUDENTS (MEASURED BY ATTITUDE, INTEREST, AND ABILITY TESTS), AND PROGRAMED INSTRUCTION VARIABLES (RESPONSE MODE, FEEDBACK, AND PREFERENCE FOR RESPONSE MODE). IN EXPERIMENT I, SUBJECTS NUMBERED OVER 350 COLLEGE FRESHMEN ENROLLED IN TWO SECTIONS OF REMEDIAL MATHEMATICS. SECTION COMPOSITION WAS NON-RANDOM, AND STUDENTS WERE AWARE THAT ONE SECTION WAS AN EXPERIMENTAL GROUP (WHICH HAD CHOICE OF RESPONSE MODE), AND ONE A CONTROL (TAUGHT BY CONVENTIONAL TEXT). ANALYSIS OF VARIANCE ON CRITERION ACHIEVEMENT TESTS FOR EXPERIMENTAL SUBJECTS ONLY SHOWED NO SIGNIFICANT DIFFERENCES FOR PROGRAMED INSTRUCTION VARIABLES AND FEW CORRELATIONS OF INDIVIDUAL DIFFERENCES AND ACHIEVEMENT TESTS WERE SIGNIFICANT. CORRELATIONS BETWEEN EDUCATIONAL TREATMENTS AND INDIVIDUAL DIFFERENCES WERE NON-SIGNIFICANT. IN EXPERIMENT II, PREFERENCE FOR FEEDBACK WAS VARIED INSTEAD OF RESPONSE MODE, BUT WITH NO CONTROL GROUP. ALMOST 250 STUDENTS IN A PSYCHOLOGY COURSE PARTICIPATED IN THE TWO DAY EXPERIMENT, AND OVER 87 PERCENT CHOSE THE FEEDBACK CONDITION, THUS ELIMINATING AN ANALYSIS OF PREFERENCE. THE SAME CRITERION ACHIEVEMENT TEST WAS GIVEN BEFORE AND AFTER EXPOSURE TO FOUR PROGRAMED EXPERIMENTAL TREATMENTS. CORRELATIONS ON DIFFERENCE SCORES FOR TREATMENT AND INDIVIDUAL DIFFERENCES DID NOT DIFFER. (LH)

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Interaction of Individual Differences with Methods of Presenting Programed Instructional Materials by Teaching Machine and Computer

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Table of Contents

	Page
Acknowledgements	ii
List of Figures	iv
List of Tables	v
Introduction	1
Objectives	20
Experiment I	20
Results	30
Experiment II	43
Results	44
Discussion and Conclusions	53
Summary	55
References	56
Bibliography	59
Appendixes	
Appendix A	A-1
Appendix B	B-1
Appendix C	C-1
Appendix D	D-1
Appendix E	E-1
Appendix F	F-1

List of Figures

Page

Figure 1. A hypothetical illustration of the interaction of educational treatments and individual differences. 12

Figure 2. A scattergram of subjects whose pre-test scores under both feedback and no-feedback conditions were identical 52

List of Tables

Page

Table 1. Results of six representative studies in which the effects of IQ on a post test (not gain score) were assessed.................... 13

Table 2. Results of four representative studies in which the effect of IQ on gain score was assessed...................................... 16

Table 3. Distribution of experimental subjects by university level, curriculum, class and sex.. 22

Table 4. Percentage of students enrolled in Mathematics 082 responding to five questions about their age, sex, and high school experience... 23

Table 5. Frequency distribution of students falling in various percentile groups on different ability tests...................................... 27

Table 6. Distribution of students by experimental conditions... 29

Table 7. Treatment X levels design and number of subjects.. 30

Table 8. Means and standard deviations for tests (choice vs no choice) and levels................. 31

Table 9. A choice X levels AOV for the three major tests... 32

Table 10. 2 x 2 AOV and number of subjects................. 33

Table 11. Means and standard deviations for test answers (multiple choice vs constructed) and mode (overt vs covert)........................ 34

Table 12. Analysis of variance of tests, answers (multiple choice vs constructed), and mode (overt vs covert)............................ 35

Table 13. Three analyses of variance: departmental final, section mid-term, section final........... 36

List of Tables (Continued)

Page

Table 14. Number of students from programed and control sections passing, failing, and dropping out of remedial mathematics.............. 38

Table 15. Number of students passing and failing departmental final from programed and control section................................. 39

Table 16. Overall correlation between individual difference variables and program final and departmental finals.......................... 40

Table 17. Correlations (with Ns) between individual difference measures and final test for three educational treatment pairs................ 42

Table 18. The design of Experiment II....................... 45

Table 19. Ns, means and standard deviations for Psychology 151 (Experiment II).................. 46

Table 20. Analysis of variance for Psychology 151 (Experiment II).............................. 47

Table 21. Correlations between difference scores on pre and post-achievement tests for the two conditions (feedback and no feedback) and various individual difference measures.............................. 48

Table 22 Comparisons between correlations based on pre and post-test scores with correlations based on difference scores........... 50

Table 23. Number of students preferring feedback or no feedback with mean level of stated preference and standard deviation................. 51

INTRODUCTION

One of the more controversial questions in education today concerns the extent to which machines, particularly computers, are to be used as teacher surrogates in the classroom of the future. Discussions of this issue frequently focus on computers and their logic, when, in fact, there are critical, prior psychological questions. Perhaps the most urgent of these psychological questions concern individual differences among students and the relationship of these differences to programed learning.

For many students and teachers, the computer and the IBM card are symbols of an automated society which is dangerously depersonalized. Higher education in particular, according to these students and teachers, must remain a highly personal interaction between teacher and student, and machines are threatening to break this connection.

In contrast, advocates of computer aided instruction (CAI) assert that the computer will restore at least some of the responsiveness to individuals which has been lost in recent years. They remind us that at many universities the large lecture involving 500 to 1000 or more students, is commonplace, and, not infrequently, closed circuit television is used as a means of extending these lectures to overflow audiences.

The argument to support the proposition that CAI can be more responsive to individuals than what we now have is frequently couched in cybernetic terms (Uttal, 1967; Prokof'yev, 1966). The cybernetic position generally defines a student as a control mechanism. One of the key characteristics of such mechanisms is the use of feedback to adjust, modify, and control behavior. When viewed in this light, human learning becomes a kind of search behavior (Smith and Smith, 1966). The student develops and evaluates hypotheses about the world and engages in a continuous search for confirmation of these hypotheses. Feedback is critical to the evaluation of these hypotheses. The cybernetic position resembles Tolman's Sign-Gestalt theory (Tolman, 1932) in that it is more purposive and molar than are other more commonly cited theories of learning.

Mager (1961) recently conducted a study which helps to clarify this difference. Although Mager was not concerned with differences between the cybernetic position and traditional learning theory, his study highlights contrasting attitudes about how humans learn. Mager arranged a situation in which students could learn elementary electronics. No assumptions were made regarding the best arrangement of the subject matter. This was left entirely up to students who, working directly with tutors, were free to ask whatever questions they wished. Students were allowed to cut off answers at any point and pose new questions. They were permitted to end sessions when they were satisfied; and so on.

Thus, the individual student could behave as a true "control mechanism," generating hypotheses, getting feedback, and adjusting his behavior accordingly. Mager concluded, among other things, that "the content sequence most meaningful to the learner is different from the sequence guessed by the instructor to be most meaningful to the learner" (p. 412).

Obviously, the instructional methods common to higher education are radically different from the methods used by Mager. Whereas Mager stresses the element of individual student control and feedback, large lectures and even small group discussion militate against them. Another way of putting this is to say that many of the instructional techniques commonly used today involve open systems, i.e., they contain almost no provision for student feedback. And what is perhaps equally significant, allow very little, if any student control.

One of the most obvious advantages of many of the new approaches to education, (particularly those involving computers) is that they lead to a greater individualization of instruction. Mager's approach illustrates one extreme on a continuum. The students' interaction with the data source and his control over it in Mager's study is more or less complete. It is, of course, possible to visualize a computer system which would literally replace (and indeed, go beyond) the teacher in Mager's study. Such a system would allow the student to progress at his own rate, give him access to any materials he needed, and in effect, be responsive to his every command. The computer, in this case, would respond primarily as a gigantic information retrieval system. While such CAI systems are conceivable, they are--for the time being at least--impractical.

There is, of course, a middle ground between the position illustrated by Mager's study and the current state of affairs in higher education. This middle-ground encourages feedback and some student control, but also, stresses the diagnostic and prescriptive role of the teacher or teacher surrogate, e.g., a computer. According to this conception, the student and the teacher or surrogate are interacting control mechanisms with a single objective, i.e., the modification of the student's behavior along prescribed dimensions. Those who advocate this approach frequently state their argument in these general terms:

> Probably the ideal teaching situation was Mark Hopkins on one end of a log and a student on the other. The student was an integral part of the system. He could raise questions, test his ideas out on the teacher, get feedback on

> his performance; and so on. The teacher, in turn, could assess the student's level of achievement, adjust his discussion of the subject matter, assignments, and methods to the individual student. Since that time, so the argument goes, the Hopkins-log-student model has gradually been diluted to a point where the teacher is used primarily as an input device, almost totally unresponsive to individual differences among students. It is no longer feasible to allow every student to have a human tutor, but it will be possible in the near-future to allow every student to interact with a computer which can be programed to diagnose the student's abilities and his prior learning and prescribe an optimal course of learning.

This argument, in general, is the CAI position. The belief that CAI, at least partially, can solve the problems of mass education is premised on the assumption that the computer will be more acceptable than other mechanized methods of teaching because it will be more responsive to individual differences; and that it will be more cost/effective than competing instructional innovations, i.e., it will be at least as effective as other means and cost less per student hour of instruction. Even if the computer is perceived by students as just another depersonalized and automated approach to education, it may nevertheless still be a more cost/effective teaching tool than competing methods. Thus, the most significant and persuasive argument for the computer, when compared to the programed text, or CCTV, or a conventional text, for that matter, lies in the fact that it--like Mark Hopkins--will be able to diagnose the individual's learning requirements and prescribe a course of action in a more cost/effective manner than other methods.

Out of these considerations there emerges a series of questions which are critical to the issue of whether or not computer aided instruction can help to solve, in a cost/effective fashion, many of the instructional problems facing higher education.

First, to what extent are individual differences important to learning, particularly programed learning of the type most apt to be used for computer aided instruction?

Second, given that differences among people are important to programed learning, are these differences equally relevant or are some more relevant than others?

And finally, do we know enough about individual differences to write the computer programs necessary to diagnose the differences and prescribe appropriate educational treatments?

It is important to note with respect to each of these questions that, while they are critically related to computer aided instruction, computers and CAI programs are not necessary to answer them. Indeed, these questions are the prior, psychological questions upon which the case for CAI rests, and it could well be argued that elaborate equipment tends to lead the investigator to emphasize hardware as opposed to these more basic issues. This, in fact, has often been the case. Accordingly, in studying this problem, no special consideration has been given to the relatively limited research in this area which has been done with computers, nor have computers been used as part of the instructional process.

Are Individual Differences Important to Learning?

The fact that men differ from one another along a number of dimensions has probably never been seriously questioned. Differences in physical prowess, age, and sex are easily discriminated and obvious to the most casual observer. Even psychological differences are readily apparent, and novelists, philosophers, and poets commented on these before the emergence of scientific psychology.

A large part of the interest in individual differences stems from the so-called nature-nurture controversy. Interest in this question led Sir Francis Galton to embark in the late 1800's on the first scientific studies of individual differences. In 1869, he published one of the classic articles in the field of individual differences, "Classification of Men According to their Natural Gifts" (Galton, 1869). Galton began the systematic collection of scientific data about individual differences (both physical and psychological differences) in his anthropometric laboratory in the South Kensington Museum, London, in 1882. Since psychological tests are basically designed to measure individual differences, Galton is generally credited with setting into motion one of the two or three main streams of contemporary psychology.

A second stream had its origin in the laboratory of Wilhelm Wundt in 1879 in Leipzig. Wundt was a physiologist and experimentalist by training and it is not surprising that the procedures he developed for studying psychological questions reflected his background. Individual differences were a nuisance to Wundt or "errors" which interfered with and presumably masked underlying psychological uniformities. This attitude toward individual differences still characterizes the work of many learning psychologists who are concerned primarily with uniformities of behavior and use averaged experimental results. Because psychologists so often interpret their results in terms of averaged data, it may well be that important differences among major learning variables are masked. Jensen (1963) makes this same point when he observes:

> "Without such study (of individual differences) we cannot properly assess the relative importance of other parameters in learning efficiency, such as schedules of reinforcement, spaced vs massed practice, stimulus and response similarity, whole vs part learning, etc...... It may well be that some subjects do better and others do worse under massed than under distributed practice (for example), so that only on the average does this particular variable appear to be of slight importance" (p. 221).

The two streams--one originating with Galton and the other with Wundt--have met occasionaly in the intervening years. Edward Lee Thorndike, who became deeply embroiled in the nature-nurture controversy (on the side of nature), investigated the problem using experimental methods and thereby initiated a new approach (Thorndike, 1908). Hull, an experimentalist, acknowledged the importance of individual differences and clearly recognized their relevance to the development of the primary laws of behavior (Hull, 1945). But, in general, despite occasional nods of recognition, the two lines of investigation have gone their separate ways.

One of the most basic observations we can make about human learning is that people differ from one another. Take any task to be learned and any randomly selected group of people, require that this group learn the task, and variability in performance will be observed. Some people will learn the task faster than others; some will retain what they learned longer than others; and so on. A careful observer may also note that subjects approach the task in different ways. Some subjects listen to the instructions and proceed to work without further questions or delay; some ask a great many questions; some make excuses and so on.

The observation that people differ in regard to such gross variables as rate of learning or style of learning is accurate but not particularly precise. If the same individual is observed in a number of different learning situations, one can begin to refine these observations and hypothesize the existence of "intervening variables" or special abilities, e.g., memory, accounting for the differences. While such factors have also been observed for literally thousands of years, the precise measurement and observation of individual differences in this regard began as we have noted with Sir Francis Galton about the middle of the last century.

Largely as a result of the work of Sir Francis Galton, the psychological testing movement was launched. The growth of this movement in America results, in part at least, from the interest of James McKeen Cattell in individual differences. Cattell, who studied for his doctorate at Leipzig completed a dissertation on individual differences in reaction time and then moved on to England where he pursued Galton's work.

The relevance of psychological testing to individual differences should be obvious. Psychological tests are designed to measure individual differences. Thus, the entire psychological testing movement is premised on the assumption that individual differences in abilities and aptitudes not only exist, but can be measured as well. Even today, some 100 years after Galton, there is not universal agreement regarding the "structure of the intellect." It may well be we know more about what the "intellect" is not, than what it is. It no longer appears to be describable by a single, unitary, all-encompassing concept like intelligence. Instead it appears to be the resultant of several different independent abilities.

J. P. Guilford (1959), who has spent the past twenty years defining the critical psychological dimensions along which people differ has concluded after intensive research that there are, in fact, five major groups of intellectual abilities: (1) factors of cognition, (2) memory, (3) convergent thinking, (4) divergent thinking, and (5) evaluation.

A related effort was undertaken in late 1951 when the Educational Testing Service convened a conference of persons interested in multiple factor analysis. This group recommended that a project be organized to identify and select tests to measure established cognitive factors. The final result was the development of a kit containing tests to measure some 24 different aptitude or achievement factors.

What is a reasonable answer then to our first question regarding the existence and nature of individual differences?

Briefly, it is this. While there may have been serious argument in Galton's day, regarding the existence of true psychological differences among individuals, there seems to be little question on that score today. The work of laboratory oriented experimentalists from Thorndike to Hull and the efforts of psychologists involved in the testing movement, testify to the existence of psychological differences among people.

The ways in which people differ physically from one another are, more or less, obvious. The case is not nearly as clear-cut however when we ask in what ways people differ psychologically, particularly in their ability to learn which is most critical from the point of view of the present study. While it is possible to assert with considerable confidence that people do differ in their ability to learn, it is not easy to describe accurately the ways in which they differ in this regard nor is there consensus on this matter.

In What Ways Do People Differ in Their Ability to Learn?

It is difficult to explore the question of individual differences very deeply without confronting the nature-nurture controversy. Indeed, a large part of the work on individual differences has been done in this context. As we have already noted, it was Galton's interest in this question that led him to undertake a program in anthropometrics and psychometrics--thus initiating the testing movement.

In the early decades of this century, the prevailing view held that cognitive abilities, particularly intelligence, were relatively fixed and immutable (Boring, 1950, p. 570-578). When this belief is combined with the conviction that general intelligence measures ability to learn, a second widespread misconception of the early 1900's, the implications for education and training are profound. For example, these views could be used to support a non-equalitarian and aristrocratic approach to education. In fact, one of the early investigators in this area, E. L. Thorndike, used the new science of experimental psychology to study these questions and like Galton, found himself on the side of nature--so much so in fact that it has since been argued he was anti-equalitarian (Curti, 1959).

E. L. Thorndike chose to attack the individual difference problem by studying the effects of practice on relative performance (1908, 1922, 1938). Does practice increase differences among individuals or does practice decrease differences? Do people become more alike, or less alike, after equal amount of practice? The relationship of this question to the nature-nurture controversy was first described by Thorndike in 1908 (p. 383-384).

> "Experiments in practice offer evidence concerning the relative importance of original nature and training in determining achievement. In so far as the differences amongst individuals in the ability at the start of the experiment are due to differences of training, they should be reduced by further training given in equal measure to all individuals. If, on the contrary, in spite of equal training, the differences amongst individuals remain as large as ever, they are to be attributed to differences in original capacity."

This general question has been studied extensively but the outcomes are so dependent on such factors as the definition of equal amounts of practice, the measure of progress selected, differences in scale intervals, and the measure of variability used, that no final conclusions seem possible. Thorndike's work tended to support the view that hereditary factors were most critical. His studies were subjected to severe criticism, however, and the weight of the evidence as reported by Kincaid (1925) and others (Hamilton, 1943) does not seem to support his contentions.

Confidence in the immutability of intelligence as measured by tests and the relative importance of heredity was further undermined by a series of studies demonstrating that practice significantly improves performance on so-called "mental tests" (Adkins, 1937; Terman and Merrill, 1937). Thus, for example, Gates (1928) studied the effect of practice on memory span for digits with experimental (practice) and control (no practice) groups and found that practice led to a significant advantage for the experimental group. Other studies (Thorndike, 1922) have shown that repeated administrations of different forms of the same intelligence test result in improved scores and even administering a different intelligence test as a retest (Rodger, 1936) has sometimes resulted in slight improvement. Guilford's recent suggestion that "possibly every intellectual factor can be developed in individuals at least to some extent by learning" (1959, p. 477-479), is just about 180° out of phase with the view that prevailed at the time of the first World War.

The notion that intelligence tests measure ability to learn has also gone by the boards. Some of the most important studies in this area were done by Woodrow (1940, 1945) who demonstrated that learning as measured by gain scores on specific tasks, is almost unrelated to intelligence. Since that time the evidence appears to support the view that learning is largely a matter of specific factors--or that learning ability is relatively specific to the task.

Jensen's recent study (1963) of learning ability in retarded, average, and gifted children clearly refutes the notion that the standard IQ test measures learning ability. Indeed, Jensen asserts, and he is by now in the best of company, that the standard IQ test measures achievement, "and tells us more about what the child has learned outside the test situation than about his learning capacity, per se." When Jensen tested children of very different IQ's on a relatively culture free learning task, he found large individual differences among these students in speed of learning. "The two fastest learners," he observes in the study cited above, "had IQs of 147 and 65!"

In the context of twentieth century educational technology, the nature-nurture controversy which so intrigued Thorndike seems less relevant than it apparently was in the early 1900's. What does seem relevant is the development of techniques for distinguishing between individuals that will help us to prescribe uniquely effective training sequences.

Robert Gagné (1962) has argued persuasively that the least dependable individual difference measures are those that purport to reflect general proficiency or aptitude, e.g., "general intelligence." The most useful measures of individual differences according to Gagné, are learning sets. By the term "learning sets" Gagné appears to mean the capabilities that a person brings to a task largely as the result of prior training and experience. He summarizes his position as follows:

> "The major methodological implication of this paper is to the effect that investigations of productive learning must deal intensively with the kind of variable usually classified as individual differences. One cannot depend upon a measurement of general proficiency or aptitude to reveal much of the important variability in the capabilities people bring with them to a given task...... But, the measurement of their learning sets.....revealed a great deal about how they would behave....(p. 365).

This quotation stresses the relative importance from Gagné's point of view of individual difference arising out of prior experience. When any given task is broken down into sub-tasks (a critical step from Gagné's point of view) and progressively more subordinate "learning sets" are identified, it may well be found that the most basic and elementary sub-tasks involve "learning sets which are very simple and general, and likely to be widespread within the population of learners for which the task is designed," i.e., basic cognitive factors. Guilford, as we have already noted, has taken the position that even these basic factors may be improved to some extent by learning.

What do comments about the ways in which people differ imply for computer aided instruction?

It has been observed that the case for computer aided instruction hinges primarily on the argument that the computer is capable of responding to individual differences among students. One critical question, of course, is which individual differences should the computer measure and respond to? The work of Gagné suggests that it is more critical to measure relatively specific prerequisite entry behaviors than some abstract variable like "general intelligence." Thus, perhaps the most critical way in which people differ (from the point of view of CAI) is in terms of prior learning and the degree to which prior learning is transferred into the training situation. In addition, Jensen has assumed that there are separate and identifiable learning abilities, but he does not yet claim to know what they are. A knowledge of these learning abilities would, of course, be invaluable for the design of individualized instructional sequences.

About all that can be said with any degree of confidence is this: We know that general intelligence is not a particularly useful measure for instructional design; it will probably be essential to conduct careful task analyses and identify prerequisite "learning sets" or entry behaviors before we can tailor learning sequences to individual needs and requirements; special, as yet undefined, "learning abilities" may be critical to the design of instructional sequences; and finally, these special "learning abilities" and related "cognitive factors" may be trainable to some extent at least.

People clearly differ in ways other than those discussed up to this point. There are obvious physical and sexual differences among people but these appear to be relatively unimportant unless the task to be learned involves special psychomotor capabilities. Age is, of course, a major variable in learning but a discussion of this area is beyond the scope of this introduction.

Do We Know Enough About Individual Differences and Their Interaction with Educational Treatments to Design the Most Efficient Instructional Sequences?

Unfortunately, a complete knowledge about individual differences is till not enough to design the most satisfactory individualized instructional sequences. To prescribe a course of action for a learner, we need to know a great deal about him, of course, but we also need to know something about how the individual differences we have measured interact with educational treatments. This leads us to the last and perhaps most critical question.

We have noted that there are extensive and significant differences among learners. We have also observed that two of the most significant sources of individual differences arise as a result of transfer from prior learning and differences in inherited learning-related abilities.

The question which now arises is this: Given these differences can we identify with any degree of certainty the modes of instruction from which different individuals will profit most? Do we know how to select educational treatments based on individual differences that will insure every student of the best chance of learning a given set of material? Do we have the necessary information to program a computer to take advantage of these individual differences in prescribing unique instructional sequences for students?

The answer to all three of these questions is, no! What can be said with a reasonable degree of confidence is that some individual differences apparently interact in complex ways with educational treatments. But, a great deal of research will have to be done before we can confidently measure individual differences in a way which will permit us to prescribe the best course of study for any given student.

From a methodological point of view, the problem may be stated in terms of regression lines for treatments and individual differences. Assume, for example, that two different educational treatments (e.g., massed vs spaced presentation of material) have been used to train a group of students differing from one another along some measured dimension (e.g., intelligence). If regression lines are drawn for each of these two treatments (Fig. 1), it is possible to make certain predictions about the outcomes:

1. If the regression lines coincide, the treatment has no effect.

2. If one line is significantly elevated above the other and they are essentially parallel the treatment represented by the upper line is superior.

3. If the slopes of the two lines differ significantly, (as in Fig. 1) then an interaction of the treatments with individual differences exists and cutting scores on individual difference measures can be used and evaluated even though there is no overall treatment effect.

Thus, if, for example one treatment is positively correlated with intelligence and the other negatively correlated (or not correlated at all), it is possible to prescribe treatments which will result in better learning for some individuals than others. In the case illustrated in Fig. 1, massed practice would be prescribed for high ability subjects but not low ability subjects.

Although not generally stated in terms of the relationship of regression lines (except by Chronbach, 1967) the problem of individual differences and educational treatment has received considerable attention in recent years from psychologists concerned with programed learning. Individual difference variables studied have included general intelligence, personality, motivation, and inhibition. The variable which has received the most attention is general intelligence.

Table 1 summarizes a number of studies of general intelligence and its relationship to performance with programed material. Although most of the studies reported in this Table were directed primarily at determining the effects on performance of a specific educational treatment, e.g., branching vs a fixed sequence, the interaction of intelligence with a final criterion measure is also reported.

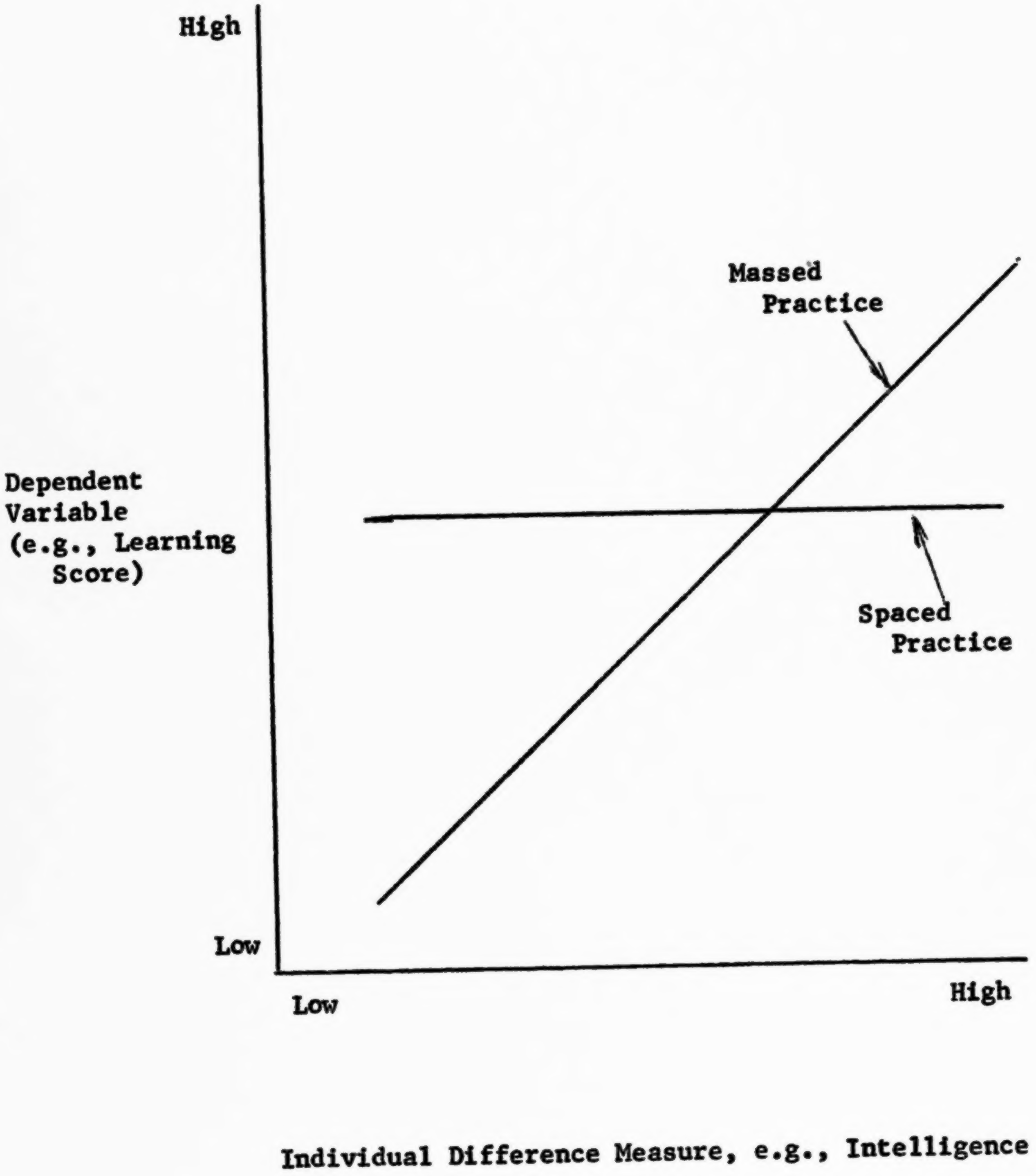

Figure 1. A hypothetical illustration of the interaction of educational treatments and individual differences.

Table 1

Results of six representative studies in which the effect of IQ on a post-test (not gain scores) was assessed. Primary purpose of the study as noted, was generally to determine the effect of an educational treatment.

Authors	Major Variables	What is Learned?	By Whom?	How?	Dependent Variables	Principal Results
Silberman, et. al. (1961)	Branching vs fixed sequence	Logic	High School Students	Program Cards -- Computer G-15	Post-test	1. Branching not superior to fixed sequence. 2. IQ correlates significantly with final scores.
Shay (1961)	Step-size	Roman Numerals	Elementary Education Students (Three IQ Groups)	Programed Booklets	Post-tests: New Items Old Items Total	1. Step size unrelated to performance (except log time). 2. No relation of intelligence and step size (except percent of errors). 3. Ability (IQ) significant for all measures using analysis of covariance.
Rogers-Quartermain (1964)	Sequence and Step Size	Roman Numerals	Elementary Education Students (Two IQ Groups on Otis: High and Low)	Programs	Post-test Errors, Time	1. Sequence variables had a significant effect on errors. 2. High IQ Ss significantly superior on all measures.

Table 1 (Continued)

Authors	Major Variables	What is Learned?	By Whom?	How?	Dependent Variables	Principal Results
Lubin, S. (1965)	Reinforcement Schedules Autonomy Need	Introductory Psychology	College Students	Programed Text	Post-test	1. Reinforcement significant. 2. High autonomy need poorer than low autonomy need!! 3. High aptitude (IQ) score significantly higher.
Beane (1965)	Branching vs. Linear Sequence	Plane Geometry	High School Students	Programed Text	Post-test	1. No significant difference branching-linear, except time. 2. High ability exceed low ability. 3. Linear Program preferred.
Williams (1965)	Training Mode. Type of Test Item. High and Low Aptitude.	Grouping "Animals"	108 Sixth Graders	Constructed Response and Multiple Choice Programs	Pre, Post, and Gain Scores	1. High aptitude Ss significantly better on all measures (CR test but not MC test) (Exceptional findings)

In general, it will be noted that intelligence interacts significantly with final criterion test scores. This, however, is not always the case, and intelligence is seldom related differentially to educational treatment.

Two factors have been cited to account for the conflicting results noted with respect to correlation (or lack of correlation) between criterion tests and intelligence.

First, an inspection of Table 1 reveals that most studies reporting a significant correlation are based on post-test scores only and are not based on gain scores (Table 2). Since it is now wisely conceded that one of the things intelligence tests measure is prior learning, it is reasonable to predict that high IQ students will enter the training situation with more information about the subject matter. It is therefore predictable that these students will score higher on a post-test and that there will be a significant positive correlation between post-test and intelligence. On the other hand, if the measure of final performance used is the difference between pre- and post-test scores no such advantage would exist for high IQ students and presumably a fairer evaluation would result.

The value of general intelligence as an individual difference measure for prescribing educational treatments has been seriously questioned. Gagné's emphasis on transfer from prior learning, as opposed to more general measures, has already been discussed. His study with Dick (1962), also reinforces this opinion. Shay (1961) concluded that IQ differences were not significant in decisions regarding step size. Jensen (1963) has made a convincing case for the low correlation between various learning tasks and IQ--another finding which we have already discussed. Eigen and Feldhusen (1964) found a significant correlation between post-test and intelligence but when the effect due to pre-test was partialed out, the significance disappeared. The Eigen and Feldhusen study, in fact, lends considerable support to Gagné's contention that transfer from prior experience is the most significant determinant of performance on criterion tasks. They state:

> "Thus, in neither study is IQ, per se, found to be the fundamental learner variable in programed instruction. This, and subsequent analyses, show that general achievement level of the student when he undertakes programed instruction, may be the major variable related to his success in learning, and further, that the ability of students to transfer what has been learned by means of programed instruction is determined more by how much has been learned than by IQ *per se*," (p. 383).

Table 2

Results of four representative studies in which the effect of IQ on gain scores (or equivalent) was assessed. Primary purpose of the study, as noted, was generally to determine the effect of an educational treatment.

Authors	Major Variables	What is Learned?	By Whom	How?	Dependent Variables	Principal Results
Eigen and Feldhusen (1964)	Individual Differences: Attitude, Intelligence, Reading Ability.	Sets, Relations Functions	High School Students	Machines and Programed Text	Post-test (but with pre-test partialed out)	1. Role of general mental ability questioned. 2. Achievement level at one stage is significant determinant of achievement at next stage. 3. Attitudes and achievements correlate more highly for older Ss.
Feldmen, M. (1965)	Programed Materials vs Text, Difficulty Level, Individual Differences	Introductory Psychology	144 College Sophomores	Text and Program	Transfer Test Gain Score	1. Verbal ability important to final performance but unrelated to gain scores.

Table 2 (Continued)

Authors	Major Variables	What is Learned?	By Whom?	How?	Dependent Variables	Principal Results
Jensen (1963)	Individual Differences	Stimulus-Response Relationships	Retarded Ss = 36 Average Ss = 24 Gifted Ss = 13	Machine	"Index of Learning"	1. Great heterogenity within groups. (Supports general contention but not strictly a measure of gain score.)
Traweek (1964)	Personality Variables and Programed Instruction	Arithmetic Fractions	186 Ss Fourth Grade	Programed Instruction	Pre and Post-tests	1. No significant differences between successful and unsuccessful groups with respect to IQ.

Stolurow has, also, taken the position that "general ability measure is outmoded for school purposes," i.e., specifying educational treatments. Stolurow, however, focuses his attention on specific tests of abilities which he believes will be useful for individualizing instruction. This conclusion is based on a series of studies which began with an experiment done with Detambel in 1956, not in the area of programed learning, but concept learning. In that study, Stolurow and Detambel found that low ability students did not do as well as high ability students with a poorly sequenced (organized) set of materials, but did as well as high ability students when the sequence was well organized. Stolurow and Cartwright (Stolurow, 1964) found something similar to this when they presented high ability and low ability students with well organized and carefully sequenced materials, and poorly sequenced (mixed) materials. On the other hand, specific abilities, (e.g., reading comprehension) correlated significantly with the sequenced materials. To Stolurow this observation "suggests the possibility of a truly individualized instruction." "Our data," he goes on to say, "suggest that one way to individualize instruction would be to sequence a set in such a way as to make maximum use of individual's abilities."

With respect to the interaction of other individual difference measures than general intelligence and programed instruction, the results are scattered and inconclusive. No firm conclusions can be drawn. The following weak generalizations or hypotheses are suggested:

1. Originality, defined as the ability to make many controlled associations to a specific stimulus may be positively correlated with performance on programed materials. (Stolurow, 1964)

2. Students who generate reactive inhibition quickly do better with programed instruction. (Schoer, 1966)

3. Low autonomy students do better than high autonomy students using programed materials. (Lubin, 1965)

4. Programed instruction improves the performance of low achievers. (Yarney, 1964)

5. Successful learners with programed materials are: more test anxious, more withdrawn, and less self reliant. (Traweek, 1964)

6. There is no relationship between attitude toward programed instruction and achievement on programs. (Doty, 1964)

7. Students who learn best using programed materials have low social needs. (Doty, 1964)

8. There is a negative correlation between achievement on PI and creativity when creativity is measured by variety of tests. (Doty, 1964)

9. There is no correlation between achievement need and PI. (Doty, 1964)

One final question regarding individual differences is relevant to the present study. Recently, the attention of some researchers has been directed toward student controlled instruction. The results of one of Mager's studies in this regard has already been discussed (p. 1-2). This general notion tends to run counter to the line of research suggesting that the computer should control the student's instruction based on relevant data on the student (see Stolurow for example). The question of control of programed learning treatments can be viewed as a problem in decision making. If a treatment has a different effect on the learning for different students, and the student can select the best treatment for him, then the student should decide which treatment to get. If, however, the student is not able to select the best treatment, then the computer should be studied as a possible alternative for making the treatment decision on a probability basis. Data on the interaction of treatments with individual differences need to be collected and analyzed to answer these questions.

Any review of the programed instruction-individual differences literature would be incomplete if it ignored some of the more obvious problems connected with the interpretation of studies in the area. Some of these problems have already been noted. Experimental subjects are commonly drawn from different age and educational groups; the subject matter programed varies in content and difficulty from group to group; control of individual differences due to prior learning has often been ignored; and so on. As might be expected, variability of experimental conditions has led to wide variability in results. Indeed, so confusing is the general picture that one is tempted to echo Ebel's (1967) lament regarding the status of education as a science; anyone who carefully reviews the literature is apt to share his scepticism over the lawfulness to be expected and discovered when the system being studied is a man-made rather than a natural system.

Two qualifications regarding past research can be made. Very often, the programed sequences used have been very short, consisting of one or two hundred frames or even less. Such short sequences as these may not have been long enough to allow individual difference variables to exercise their effect on the final outcome. And, second, the number of subjects participating in any given experiment has often been very small. Illustrative N's have been included in Tables 1 and 2.

Objectives

Two major experiments were designed with the following objectives:

1. To determine whether certain major parameters of programed instruction interact with individual differences among a large group of college students when a complete and extensive programed sequence is used.

   Individual difference measures employed in the two studies included: (a) tests of information, verbal, mathematical, reading, and general ability; (b) attitudes toward instructional methods and learning; (c) attitudes toward mathematics (the course sequence used in one of the studies); (d) vocational interest; and (e) three tests of special abilities.

   The parameters of programed instruction used in the experiment were: (a) overt vs covert responding; (b) constructed vs multiple choice response (Experiment I); (c) choice vs no choice (Experiment I); (d) preference vs no preference (Experiment II); (e) feedback vs no feedback (Experiment II).

2. To determine whether college students are able to select a method of programed instruction which will provide optimum learning conditions for them.

3. To help establish the relative importance of various individual differences for computer aided instruction.

4. To compare the effectiveness of programed instruction presented by machine with a conventional text when used to teach a complete course in remedial mathematics (Experiment I).

Experiment I

Subjects. Experimental subjects for the first study were 189 students enrolled in one section of a remedial mathematics course (non-credit) taught at Michigan State University. Control subjects (N=180) were registered in a second section of remedial mathematics. No effort was made to control the assignment of subjects to sections and it was assumed that the major determinant of section choice was the day of the week the course was offered, a consideration which presumably did not adversely affect random sampling.

Entering freshmen at Michigan State are required to take the MSU Mathematics Test together with other entrance examinations. Those receiving a score of 13 or less are not eligible for courses in the Mathematics Department until they get a passing grade in remedial mathematics (Mathematics 082) or obtain a score of 14 or above on retest. Students from both sections enrolled in the remedial mathematics course in order to meet this eligibility requirement. Enrollment for the course did not guarantee attendance. Indeed, attendance is not required and traditionally, classes meet only at the beginning and end of the term. Thus, the 189 Ss indicated above, include all students registering for the course. With the exception of the Chi Squares reported on page 38, all statistical tests actually involved fewer subjects than the total number registered in the course, the exact number depending on completion of tests, attendance, etc.

A breakdown of 166 of the Ss registered in Section 1 by University Level, Curriculum, Class, and Sex is presented in Table 3. Descriptive data of this kind were not obtained for students enrolled in Section 2, but it is reasonable to assume that few, if any differences would be noted.

Although all students were informed of the difference between the two sections immediately after the start of the term, approximately the same number dropped out of each section (73 from Section 1 and 65 from Section 2). The large number of drops can be partly attributed to the fact that freshmen sign up for courses immediately after taking entrance examinations, and many decide later to retake the MSU Mathematics Test rather than taking the remedial course. A small number of students registered late for both sections (18 for Section 1 and 12 for Section 2), and there were only 4 section changes for both sections. Therefore, Ss participating in the experiment were probably a representative sample of those usually enrolled in remedial mathematics at Michigan State University.

Additional data on these Ss were available as a result of several questions raised on the survey of Attitudes Toward Learning (ATL). The percentage of Ss responding to each of five questions directed at determining something about their individual backgrounds is shown in Table 4.

Individual Difference Measures. Scores on all tests routinely administered to entering students were available for analysis. These included:

> The MSU English Placement Test (E) consists of thirty-five objective test items representing various aspects of English usage: spelling, captialization, grammar, punctuation, sentence structure, and organization. Although the test is intended primarily to identify students who may require assistance from the Preparatory English Program the test has proven to be a satisfactory and convenient supplemental means of identifying students for honors sections.

Table 3

Distribution of experimental subjects by university level, curriculum, class, and sex

College	N	Major	N	Class	N	Sex	N
University College	152	Agriculture	22	Freshman	161	Single-Male	110
University College -Candidate for Provisional Teaching Certificate	11	Accounting & Finan. Adm.	12	Sophomores	3	Single-Female	56
Upper Division -Candidate for Provisional Teaching Certificate -Dual Enrollment with College of Education		Pre-Veterinary	12	Juniors	2		
		University College-Non Preference	24				
		Business Law & Office Adm.	27				
		Physical Sciences	4				
		Pre-Professional	16				
		Hotel, Rest. & Institutional Management	7				
		Elem. & Spec. Education	1				
		Medical Technology	13				
		Urban Plann. & Landscape Arch.	2				
		Marketing & Transp. Adm.	1				
		German & Russian	1				
		Engineering (no major)	12				
		Gen. Science	1				
		Elec. Engrg.	1				
		Biochemistry	1				
		Biological Sciences	2				
		Management	3				

Table 4

Percentage of students enrolled in Mathematics 082 responding to five questions about their age, sex, and high school experience

Question	N
I am a:	
1. Male.	69
2. Female.	30
I took:	
1. Less than one year of math in high school.	4
2. Between one and two years of math in high school.	33
3. Between two and three years of math in high school.	41
4. More than three years of math in high school.	22
I am:	
1. 17 years old.	15
2. 18 years old.	64
3. 19 years old.	6
4. 20 years old.	5
5. More than 20 years old.	9
In high school, I was a (an):	
1. A student.	4
2. B student.	73
3. C student.	22
4. D student.	1
My training in "mathematics" could probably best be described as:	
1. Modern mathematics.	15
2. Traditional mathematics.	75
3. Arithmetic	8

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[1] To get some idea of how these students compare on a variety of tests with the group of Psychology 151 students used in the second experiment, see Appendix F.

The MSU Reading Test (R) is a 42-item test of reading comprehension. The score is based upon the student's ability to answer questions based on reading passages representative of several academic areas at MSU. The test is not some measure of factors involved in critical thought. The test is useful to faculty members in decisions requiring some knowledge about the student's verbal ability. It is routinely used as one basis for assigning students to Reading Improvement Service and to Preparatory English.

The College Qualification Tests (CQT) are designed to measure several abilities which are indicative of success in college. The test yields four scores: verbal or vocabulary (QV), general information (QI), numerical (QN), and a total score (QT). The total score provides the best single index of college ability for MSU students in general, although QV supplemented by QI seems to relate most closely to success in courses in which verbal facility is important, such as social science and literature, while QN supplemented by QI appears to be most closely related to success in technically oriented courses which make demands on quantitative ability, such as physical science, chemistry, or mathematics.

The MSU Arithmetic Placement and the MSU Mathematics Test (Algebra) are also administered as a part of the Orientation Test battery, but students have an option to select which one of the two tests they will take. Students who plan to enroll in a beginning course in Mathematics must take the Mathematics Test, while all others must take the Arithmetic Test. The Mathematics Test, which consists of 30 items dealing with high school algebra, together with the CQT-N Test, is of value in predicting whether students will be successful in technical courses. The Arithmetic Test, consisting of 40 items in elementary arithmetic, is of value in detecting students who are deficient in basic arithmetic.

Two attitude measures, not routinely administered to freshman, were given to the Ss in this experiment.

Attitudes Toward Learning (ATL). This survey which is under development by the Learning Service at Michigan State University, attempts to assess a student's preception of himself as a learner. The survey (Appendix A) uses Lickert-Type questions to asses student attitudes in five categories: (1) Mechanical Comfort-Discomfort, (2) Desire for Teacher Contact, (3) Initiative and Participation in the Learning Process, (4) Independence in Learning (Autonomy), and (5) Ease of Learning. Questions falling within each of these five areas are shown in Appendix A. To create this scale, relevant dimensions were identified and questions developed in these categories. A factor analysis was then used to accept or reject items for inclusion within categories.

Four separate scores, one for each category except Number 3 (Initiative and Participation), were calculated for all students by summing Lickert values. Reliability for the population of this study was estimated to be .937 using the method described by Hoyt (1941).

Attitudes Toward Mathematics. A scale developed by Aiken (1960) was used to assess the extent to which Ss liked or disliked mathematics. This scale consists of twenty items, evenly divided, 10 favorable to mathematics and 10 unfavorable. The following items were included in the scale:

1. I do not like mathematics. I am always under a terrible strain in a math class.
2. I do not like mathematics, and it scares me to have to take it.
3. Mathematics is very interesting to me. I enjoy math courses.
4. Mathematics is fascinating and fun.
5. Mathematics makes me feel secure, and at the same time it is stimulating.
6. I do not like mathematics. My mind goes blank, and I am unable to think clearly when working math.
7. I feel a sense of insecurity when attempting mathematics.
8. Mathematics makes me feel uncomfortable, restless, irritable, and impatient.
9. The feeling that I have toward mathematics is a good feeling.
10. Mathematics makes me feel as though I'm lost in a jungle of numbers and can't find my way out.
11. Mathematics is something which I enjoy a great deal.
12. When I hear the word math, I have a feeling of dislike.
13. I approach math with a feeling of hesitation-hesitation resulting from a fear of not being able to do math.
14. I really like mathematics.
15. Mathematics is a course in school which I have always liked and enjoyed studying.
16. I don't like mathematics. It makes me nervous to even think about having to do a math problem.
17. I have never liked math, and it is my most dreaded subject.
18. I love mathematics. I am happier in a math class than in any other class.
19. I feel at ease in mathematics, and I like it very much.
20. I feel a definite positive reaction to mathematics; it's enjoyable.

Four tests to measure special abilities and interests were administered. They were:

> Memory Test. This test has not been standardized. It consists of 48 pairs of words with one word in each pair underlined. After two minutes of study, the words are presented to Ss in a different order and Ss are given another two minutes to select the word in each pair which had been underlined. It is essentially a verbal discrimination task using whole rather than pair presentation. Word pairs used were based on Thorndike-Lorge frequency and type of within-pair relation, associative and/or semantic similarity, and physical (sound and common letter) similarity. In preliminary try-outs, this test was easy to administer and gave a wide range of scores.
>
> Arithmetic Operations Test. This test has not been standardized. It consists of 25 incorrect equations which require a change in one or more signs to be correct. Four alternatives are given for each equation. The test was continued in these experiments until 95% of the students were finished. Time required to administer the test was 8:45 minutes to 9:00 minutes.
>
> Search Task Test. This test has not been standardized. The test requires Ss to locate, match, and copy letter-number combinations. Given the first part of each combination, Ss had to find the whole combinations among 60 items on a page and copy the last part of the combination in the answer blank. Every two minutes students drew a line below the last number completed.
>
> Strong Vocational Interest Blank for Men and for Women. The SVIB has been widely used for many years by personnel and research workers. As a result, a large number of studies, using it, have been reported. Extensive reference listings are available (Buros, 1965). The test is useful for predicting membership and, to some extent, success in given occupations. It includes a masculinity-femininity scale.

Individual difference tests were administered to most students during the first three periods at the beginning of the term. Late registrants and those who missed testing sessions for other reasons were tested individually or in small groups. Distribution of students by percentile ranking on the various aptitude tests is shown in Table 5.

Experimental Materials. A programed text in remedial mathematics, prepared at Michigan State University, was tested on a small group of 26 students prior to the beginning of this experiment. The program was revised on the basis of these tests. The form used in the present experiment consisted of 44 units with an average of about 30 frames per unit. Content followed the outline of a typical modern high school algebra course.

Table 5

Frequency distribution of Mathematics 082 students falling in various percentile groups on different ability tests

Percentile	MSU English	MSU Reading	CQT Verbal	CQT Information	CQT Numerical	CQT Total	MSU Arithmetic	MSU Math
90-99	4	9	6	10	-	1	-	
80-89	8	13	15	13	-	5	-	
70-79	15	13	23	23	4	10	6	
60-69	6	23	15	20	5	12	42	
50-59	18	12	21	28	6	21	50	
40-49	15	19	23	30	13	36	65	
30-39	24	30	22	17	41	28	32	
20-29	24	32	32	29	47	30	11	
10-19	32	26	27	24	54	29	-	119
0-9	26	33	26	19	40	38	-	62

The text was prepared in two forms, multiple choice and constructed response (completion). Programs were presented on MTA (Modern Teaching Associates) Teaching Machines. Ss advanced the program at their own rate of speed by pressing one of the control buttons. For multiple-choice programs, Ss chose one of three buttons to indicate which answer was correct. The program then advanced to a new frame corresponding to S's choice and showed him whether his choice was correct. If the choice was wrong, the program contained an explanation of the S's probable error or a step-by-step demonstration of how the question should have been answered. In the constructed response version, the correct response was indicated after each question. Problems were frequently worked out in detail so that Ss could discover for themselves where they had made errors.

Design and Procedure. The experimental design included three independent variables: multiple-choice or constructed response, overt (written) or covert response, and choice or no-choice in assignment of the first two conditions. After Ss had completed their initial unit (Appendix B) which allowed them to experience all combinations of variables, approximately one-third of the Ss were given the opportunity to express their preference for a particular combination of treatments. The original design was, therefore, a 2 x 2 x 2 factorial. The final distribution of Ss by experimental conditions is shown in Table 6. The smallest number expressing a preference for a particular combination (constructed-covert) of treatments was two. The constructed-covert condition for both choice and no-choice, was omitted from the analysis because of the potential unreliability from an N of two. The number of Ss in each choice condition was, of course, limited by the number actually choosing multiple-choice-overt; fifteen chose multiple-choice-covert; and ten chose constructed response-overt.

All Ss signed up for four study periods a week. For each study period they recorded starting time and unit number. For the overt response condition, Ss recorded their responses on plain sheets of paper, along with the appropriate question number. Paper was also available for the "covert" Ss for problems they were not able to do "in their heads." At the end of each unit Ss recorded their completion time and then filled out a review sheet on the material in that unit. They could then go on to the next unit. Ss completed an average of two units per class period and spent an average of 23.37 minutes in the room each class day.

Table 6

Distribution of students by experimental conditions

Choice				No Choice			
Multiple Choice		Constructed		Multiple Choice		Constructed	
Overt	Covert	Overt	Covert	Overt	Covert	Overt	Covert
27	15	10	2	30	25	36	24

N = 169

Results

Educational Treatments: Analysis No. 1. A 2 x 2 x 2 factorial analysis of variance was not performed since the choice-constructed response-covert cell contained only two Ss. The analysis was collapsed and the low N cell was eliminated. The first step was to see if there was any difference in the performance of choice and no choice subjects. In order to do this, subjects were randomly selected from each No Choice condition (except constructed response-covert) until the same number had been selected as were already in the corresponding choice condition (Table 7).

Table 7

Treatments X levels design and number of subjects

	Choice	No Choice
Multiple Choice-Overt	27	27
Multiple Choice-Covert	15	15
Constructed Response-Overt	10	10

In the course of the term, Ss received two section tests, a mid-term (Appendix C) and a final (Appendix D)[2] based on program content. Each of these tests was divided into two parts. One part was made up of questions requiring a constructed response; the other part consisted of multiple-choice questions. Separate scores were computed on each of these parts. In addition, a final examination was administered by the Department of Mathematics which was not specificially written to reflect program content. Indeed, although content of the programed text had been coordinated with the Department of Mathematics, the final examination (created and administered by the Mathematics Department) deviated considerably from the programed materials.

Five test scores were, therefore, available for each subject: (1) mid-term (multiple-choice); (2) mid-term (constructed); (3) final (multiple-choice); (4) final (constructed); and (5) the departmental final. The separate parts of the mid-term and final could, of course, also be summed to yield two additional measures.

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[2] Appendix D contains a table showing the distribution of raw scores of the first 44 items of the final exam (p. D-9).

Table 8

Means and standard deviations for tests (choice vs no-choice) and levels*

	Choice						No-Choice					
	Multiple-Choice Overt		Multiple-Choice Covert		Constructed Response Overt		Multiple-Choice Overt		Multiple-Choice Covert		Constructed Response Overt	
	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.	M	S.D.
Section Midterm-Multiple Choice	21.26	5.77	19.93	5.06	21.30	6.43	20.78	5.96	20.80	6.53	22.80	3.49
Section Midterm-Constructed Response	35.85	3.58	36.33	2.61	37.50	2.76	36.44	3.72	34.73	3.03	36.10	3.72
Section Final-Multiple Choice	41.33	4.07	40.80	2.56	42.80	3.81	41.37	3.72	40.13	3.42	42.00	2.26
Section Final-Constructed Response	30.52	5.03	28.33	4.25	31.90	5.13	29.81	5.60	28.60	5.42	29.40	3.78
Department Final	15.33	5.11	13.13	3.36	17.60	7.04	13.70	5.24	12.60	5.01	15.40	4.65
	N = 27		N = 15		N = 10		N = 27		N = 15		N = 10	

*Constructed response covert condition omitted (see text)

Table 9

A choice X levels AOV for the three major tests

Department Final

Source	SS	df	MS	F	
A (Choice)	2.164	1	2.164	.067	$p > .25$
B (Levels)	34.015	1	34.015	1.057	$p > .25$
A X B	17.849	1	17.849	.554	$p > .25$
Error (within groups)	3218.885	100	32.189		
Total	3272.913	103			

Section Mid-Term

Source	SS	df	MS	F	
A (Choice)	14.625	1	14.625	.401	$p > .25$
B (Levels)	124.137	1	124.137	3.406	$.05 < p < .10$
A X B	53.460	1	53.460	1.467	$.10 < p < .25$
Error (within groups)	3644.615	100	36.446		
Total	3836.836	103			

Section Final

Source	SS	df	MS	F	
A (Choice)	124.962	1	124.962	1.517	$.10 < p < .25$
B (Levels)	433.289	1	433.289	5.259	$.01 < p < .05$
A X B	59.522	1	59.522	.722	$p > .25$
Error (within group)	8238.381	100	82.384		
Total	8856.154	103			

Table 8 contains the means and standard deviations for these five test scores for the six choice-no choice groups of subjects. The number of Ss involved in each condition (N) is, also, shown.

Analyses of variance were run on the three major tests (section mid-term, section final, and department final) and the results are shown in Table 9. Choice was not a significant variable in any of the three cases.

Educational Treatments: Analysis No. 2. Since choice did not produce a significant difference in performance either for main effects or interactions, the choice and no-choice Ss could be pooled within the corresponding conditions on the other two factors. It was then possible to perform 2 x 2 AOV on the other two factors (Table 10).

Table 10

2 x 2 AOV and number of subjects

Multiple Choice		Constructed Response	
Overt	Covert	Overt	Covert
57	40	46	26

N = 169

Table 11 contains the means and standard deviations for all tests and conditions for choice and no-choice Ss combined. An analysis of variance of these data reveals no significant differences due to treatments (except tests) or interactions (Table 12).

When separate analyses of variance are run on the three principal tests (Department Final, Section Mid-Term, and Section Final), the results are essentially the same. Table 13 contains the results of the analyses for the three tests for the multiple-choice vs constructed response and overt vs covert conditions. None of the treatments or interactions are significant, at the .05 level or better.

Table 11

Means and standard deviations for test answers
(multiple-choice vs constructed) and
mode (overt vs covert)

	Multiple-Choice				Constructed Response			
	Overt		Covert		Overt		Covert	
	M	S.D.	M	S.D.	M	S.D.	M	S.D.
Section Midterm Multiple-Choice	20.95	5.72	19.88	5.87	20.87	5.85	21.54	5.58
Section Midterm Constructed Response	36.18	3.56	35.28	3.74	36.65	3.09	36.27	4.62
Section Final Multiple-Choice	41.26	3.82	40.38	3.15	41.80	3.17	41.12	3.79
Section Final Constructed Response	30.07	5.17	28.75	4.77	29.52	4.16	30.00	4.34
Department Final	14.58	5.10	12.82	4.20	14.87	5.30	13.65	5.72
	N = 57		N = 40		N = 46		N = 26	

Table 12

Analysis of variance of tests, answers (multiple-choice vs constructed), and mode (overt vs covert)

Source	SS	df	MS	F	
Between groups		168			
B Multiple-choice-constructed	73.845	1	73.845	1.810	$.10 < p < .2$
C Overt-covert	97.452	1	97.452	2.388	$.10 < p < .2$
B X C	44.749	1	44.749	1.096	$p > .2$
Error (between)	6,731.161	165	40.794		
Within groups		676			
A (tests)	76,053.216	4	19,013.304	1,154.490	$p < .0000$
A X B	4.659	4	1.164	.070	$p < .25$
A X C	37.104	4	9.276	.563	$p < .25$
A X B X C	22.053	4	5.513	.334	$p < .25$
Error (within)	10,870.196	660	16.469		
Total	100,162.01	844			
Adjustment for unequal N's	(-6,227.57)				
Adjusted total SS	93,934.44				

Table 13

Three analyses of variance: departmental final, section midterm, section final

Dependent Variable = Department Final

Source of Variance	Sum of Squares	df	Mean Square	F	
A Multiple-choice-constructed	24.471	1	24.471	.735	p >.25
B Overt-covert	1.584	1	1.584	.048	p >.25
A X B	29.510	1	29.510	.886	p >.25
Error (within groups)	5,494.896	165	33.30		
Total	5,544.532	168			
Adjusted Total	(5,550.461)				

Dependent Variable = Section Midterm

Source of Variance	Sum of Squares	df	Mean Square	F	
A Multiple-choice-constructed	73.741	1	73.741	1.832	.10< p <.25
B Overt-covert	79.639	1	79.639	1.978	.10< p <.25
A X B	4.999	1	4.999	.124	p >.25
Error (within groups)	6,642.702	165	40.259		
Total	6,814.367	168			
Adjusted Total	(6,801.081)				

Dependent Variable = Section Final

Source of Variance	Sum of Squares	df	Mean Square	F	
A Multiple-choice-constructed	32.276	1	32.276	.415	p >.25
B Overt-covert	141.401	1	141.401	1.818	.10< p <.25
A X B	53.142	1	53.142	.683	p >.25
Error (within groups)	12,829.598	165	77.755		
Total	13,083.609	168			
Adjusted Total	(13,056.417)				

Section I (Programed) vs Section II (Conventional). As previously noted (p. 20) two sections were given the departmental final. Section 1, which provided the experimental subjects for this study, used the programed text under the conditions already described. Section II which used a conventional text received no lectures, but had graduate assistants available for help sessions. This group served as a control. Content of the final examinations, which was determined by the Department of Mathematics, did not reflect, particularly well, program content (as we have already stated). Thus, for example, equations with three unknowns were included on the departmental final examination but were not covered by the program.

Coordination sessions with the Department of Mathematics did not reveal such discrepancies as these. In addition, the department recommended and approved the inclusion of content which was actually not covered in their final examination, e.g., set theory, and apparently had little relevance to the course content objectives of the department. Any interpretation of the relative merit of programed instruction vs traditional method must, of course, take these differences in stated or implied vs actual objectives into account.

Despite this qualification, an interesting observation can be made on the outcome of this comparison (Table 14). It is apparent that the control section resulted in somewhat higher percentage of students passing the final examination (53% vs 48%). On the other hand, the experimental section (teaching machine group) succeeded in holding a far larger absolute number of students (176) than the control section (110) despite the fact that both sections were of approximately equal size at the beginning of the term (189 vs 180). The significant Chi Square (54.79, $p < .001$) is undoubtedly due primarily to this as revealed by the fact that the groups do not differ significantly when the no-shows are eliminated (Table 15).

Individual Differences. One of the first and most obvious questions as regards the individual difference data is this: To what extent do the various measures of individual differences correlate with performance measures on final tests without regard to experimental (educational) treatments? These correlations are shown in Table 16 for the two most critical tests (Department and Program Finals).

A number of these correlations are significantly different from zero at the .01 level. These results are about as one might expect, mathematical ability correlates with Program Final. But, it is interesting to note that there is almost no correlation between mathematical ability and the departmental final.

Table 14

Number of students from programed and control sections passing, failing departmental final and dropping out of remedial mathematics

	Sec. I	Sec. II	Total	%
Pass	0 = 84 E = 72.8	0 = 58 E = 69.3	142	38.5
Fail	0 = 92 E = 73.7	0 = 52 E = 70.2	144	39.0
No Show	0 = 13 E = 42.5	0 = 70 E = 40.5	83	22.5
Total	189	180	369	

Table 15

Number of students passing and failing departmental final from programed and control section

	Section I	Section II	Total	%
Pass	0 = 84	0 = 58	142	49.6
	E = 87.3	E = 54.6		
Fail	0 = 92	0 = 52	144	50.4
	E = 88.7	E = 55.4		
Total	176	110	286	
Percentage Passing	48	53		

Table 16

Overall correlations between individual difference variables and program final and department final

Variable	Final Total	Department Final
Sex	-0.020	-0.103
English	0.070	-0.130
Reading	0.026	0.028
Verbal	0.036	-0.130
Inform.	0.001	-0.103
Number	0.385*	0.042
Arith.	0.264*	-0.012
Total	0.137	-0.113
Math	0.400*	0.088
Search Tk.	0.058	-0.067
SVIB-MF	0.124	0.046
Short Mem.	0.049	-0.011
Arith-Op.	0.190	-0.048
Ease-Lng.	0.090	0.130
Indep Lng.	0.152	-0.120
Mechanic	0.211*	-0.082
Teach Con.	-0.012	-0.089
Pho-Phil.	0.203*	-0.029
Units	0.518*	0.014
Mid-Term A	0.491*	-0.026
Mid-Term B	0.592*	-0.034
Mid-Total	0.610*	-0.033
Final A	0.890*	-0.029
Final B	0.914*	-0.036
Final Total	******	-0.036
Department Final	169.000	******

(*) Significant at .05 level or better.

Two tests of attitude also correlate significantly with final performance: Math-Phobia-Philia and Mechanical Comfort-Discomfort Interest of the ATL.

It is not surprising to discover that those who like mathematics tend to do better on their final than those who do not like mathematics. However, the fact that those who feel more comfortable with mechanical things appear to do better than those who do not feel comfortable with mechanical things is rather an unexpected finding. One possible explanation for this might lie in the fact that those who feel comfortable with mechanical things have a higher mathematical aptitude. None of the three mathematical ability tests (arithmetic, mathematical, or arithmetic operations) correlated significantly with the test of mechanical comfort-discomfort (.163, .060, and -.031 respectively). Another hypothesis, of course, is that those who perceive themselves "comfortable" with mechanical things do better using programed instruction via a teaching machine than those who do not feel comfortable with mechanical things.

To what extent do the various educational treatments correlate differentially with measures of individual differences? Are there differences in correlations between individual ability measures and final test performance for groups receiving different educational treatments? A general answer to this question is, "not very many and not very significant." An inspection of the correlations between the 18 individual difference measures and final test scores for all pairs of treatments, reveals only one treatment pair significantly different at the .01 level or better (reading) and two at the .05 level (Table 17). Given the fact that over one hundred correlation pairs were examined, it is hardly surprising to uncover three significant pairs. The most significant of these (reading) may permit the following weak generalization: poorer readers do best under covert conditions whereas good readers do best when they respond overtly.

Table 17

Correlations (with Ns) between individual difference measures and final test for three educational treatment pairs

Individual Difference	Educational Treatment											
	Choice		No Choice		Multiple-Choice		Constructed		Overt		Covert	
	r	N	r	N	r	N	r	N	r	N	r	N
Ease of Learning	.311	57	-.019	108								
Math. Phobia-Philia	.007	55	.329	105								
Reading									.178	105	-.251	66

Experiment II

A variable not included in Experiment I was feedback vs no feedback. A study was undertaken to investigate the effect of this variable and its interaction with individual differences. The general experimental conditions closely paralleled those of the first experiment, i.e., students studied programed materials: criterion scores (based on the difference between a pre and post test) were used to evaluate performance; and the individual difference tests described above were given before the program was administered. In this case, however, the instructional program covered different subject matter (two units from Introductory Psychology) and was considerably shorter.

Subjects. Ss in Experiment II were students regularly enrolled in one section of the Introductory Psychology Course taught at Michigan State University. The experiment was conducted on two consecutive days. Out of 293 Ss enrolled in the course, 246 participated in some phase of the experiment. Of these 246 Ss, 231 took both the pre and post tests on Day 1, but only 180 took both the pre and post tests on Day 2.

Materials. Two units from a programed text for Introductory Psychology were used in this experiment (Appendix F). The text is under development at Michigan State University and has not been published. One unit covered discrimination learning (Unit A) and one unit covered the concepts of reliability and validity (Unit B). Both units were prepared with and without feedback, and presented in mimeographed booklets. Content of a booklet included the two units--one with and one without feedback--counterbalanced for order of unit and feedback conditions. The same criterion test was given before and after Ss studied a particular set of programed material. The test consisted of 8 items to be matched with 20 alternatives. A separate test was created for each of the two units.

Procedure. The entire experiment was conducted during three consecutive class sessions, the first of which was used to introduce the materials. On the first day, students were given a brief explanation of the feedback and no feedback alternatives. Having read a published programed textbook containing feedback as a class assignment, they were able to choose on the basis of prior experience. The degree of preference for their choice was indicated on a scale from 1 (makes little difference) to 5 (strongly prefer). Over 87% of the students preferred feedback, and the number of students remaining in the no feedback condition (27) precluded an analysis based on student preference.

At the next class (first experimental day) programed materials were distributed to students as they arrived. There were four different booklets, representing the two possible orders of subject matter combined with feedback and no feedback. The booklets were ordered and distributed to students as they arrived without regard to preferences.

The criterion test for the first unit was attached to the back of each booklet. Instructions at the beginning of each part, informed the students that the material they were going to study that day contained or did not contain answers to the questions. Students were given suggestions on how to study the materials, such as reading each item carefully and trying to answer the question before looking at the answers or going on to the next item.

Ss were instructed to complete the test and hand it in, after which they could begin studying the first unit. The test was not timed, but students were encouraged not to take too long. When they finished the unit, they were given the same test again. Students wrote their names on their own booklets and turned them in at the end of the first part.

The third class period was conducted like the previous one. Ss were given their own booklets and read the second unit, with appropriate pre and post tests.

Design. Four major experimental treatments were included in the experiment: (1) Discrimination-Feedback; (2) Discrimination-No Feedback; (3) Reliability-Feedback; and (4) Reliability-No Feedback. The experiment was conducted over a two-day period. The same Ss were used on Day 1 and Day 2, and all Ss received a different treatment on Day 2 than they had received on Day 1. Since the design was not completely balanced (Table 18), a separate analysis of variance was computed for each of the two days.

Results. The means, standard deviations, and Ns for each of the experimental treatments are shown in Table 19. These means are based on the difference between pre and post test scores. Analyses of variance for Days 1 and 2 are shown in Table 20. Feedback was not significant on either of the two days.

One of the major purposes of the experiment was to determine the extent to which educational treatments, i.e., feedback, no feedback, differentially correlated with ability. When difference scores between pre and post tests are used (Table 21), it is readily apparent that correlations are about the same whether or not feedback is provided. That is, correlations for treatments and individual difference do not differ significantly.

Table 18

The design of Experiment II

	Discrimination		Reliability	
	Feedback	No Feedback	Feedback	No Feedback
Day 1	Group 1	Group 2	Group 3	Group 4
Day 2	Group 4	Group 3	Group 2	Group 1

Table 19

Ns, Means, and Standard Deviations for Psychology 151 (Experiment II)
(Difference Scores)

	Discrimination						Reliability						N
	Feedback			No Feedback			Feedback			No Feedback			
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	
Day 1	57	2.088	1.815	53	2.283	1.336	63	2.873	1.690	58	3.259	1.831	231
Day 2	41	2.390	1.701	46	2.174	1.670	43	3.302	1.684	50	2.840	2.024	180

Table 20

Analysis of variance Psychology 151

(Dependent Variable = Difference score between pre tests and post tests)

	Day 1				Day 2			
Source of Variance	Sum of Squares	df	Mean Square	F	Sum of Squares	df	Mean Square	F
Topic (A)	44.598	1	44.598	15.687	27.864	1	27.864	8.675
Feedback (B)	4.854	1	4.854	1.707	5.153	1	5.153	1.608
A X B	.521	1	.521	.183	.677	1	.677	.211
Error (within groups)	645.421	227	2.843		546.154	176	3.205	
Total	695.394	230			597.848	179		

Topic Categories (A)
1) Discrimination
2) Reliability

Feedback Categories (B)
1) Feedback
2) No feedback

Table 21

Correlation between difference scores on pre- and post-achievement tests for the two conditions (feedback; no feedback) and various individual difference measures

	Feedback	No Feedback
Sex	-0.06	-0.08
English	-0.01	0.09
Reading	0.01	0.03
Verbal	-0.07	0.03
Information	-0.03	0.03
Numeric	0.06	0.07
Arith	0.00	0.11
Total	-0.02	0.06
Math	0.09	-0.04
Search	0.00	-0.14
Memory	0.02	0.03
Arith Ops.	0.08	0.14
Ease Learning (ATL)	0.05	0.01
Independent Learning (ATL)	0.11	-0.04
Mechanical Comfort (ATL)	-0.00	-0.00
Teacher Contact (ATL)	-0.07	-0.04
Math Phobia Philia	-0.02	0.06

Since difference scores presumably compensate for individual differences in initial ability, it is instructive to compare correlations based on the difference between pre and post test scores and individual differences with correlations between pre tests and individual differences and post tests and individual differences (Table 22). While several abilities correlate significantly with both pre and post test scores, it is apparent that these particular correlations virtually disappear when difference scores are used. These results reinforce the point that the measure of performance selected is critical to the outcome of studies such as these and suggest that observed correlations may be more directly related to the entry behaviors of Ss than basic abilities. Several psychologists have made the same general observation (See, for example, Sawiris, 1966).

As we have already noted the vast majority of Ss preferred the feedback condition (Table 23). Furthermore, these Ss apparently felt that feedback was very important to them (Mean = 4.1) whereas the no feedback Ss were more nearly neutral (Mean = 2.3). Two possibilities are suggested for explaining these results. First, feedback was available to Ss in the present case for a relatively small investment of time and energy. Since success was presumably more probable with feedback, Ss may have been willing to make a small investment of their time to increase the likelihood of passing the course. Second, their prior experience with programed instruction feedback may have convinced them that feedback is essential to learning with PI. No data are available to help decide which of these two factors may have been operating, and indeed, both factors may have had some bearing on their decisions.

Another important question with respect to feedback is this: To what extent are individual differences masked by the averaging of data in experiments of this kind? To answer this question, Ss were identified who had identical pre-test scores under both feedback and no feedback conditions. This insured that comparisons could be made among Ss starting from the same base conditions with and without feedback. Since Ss with high pre-test scores were probably working against an artificial ceiling (total possible score = 8), only Ss with pre-test scores of 2, 3, and 4 were used. (No S received a pre-test score of 1 on both tests.) Presumably, if some Ss "needed" feedback more than others, their performance under the two conditions should differ. Ss who learn best with feedback, for example, should show greater improvement with feedback than without. A scattergram was plotted for these Ss comparing their performance under feedback and no feedback conditions. The measure used was the ratio of post-test/pre-test (Figure 2). It is apparent that Ss show about the same improvement under the two conditions. Indeed, the correlation is $r = .71$. Feedback therefore does not appear to be an important or significant treatment variable in this study even at the individual level of analysis.

Table 22

Comparisons between correlations based on pre- and post-test scores with correlations based on difference scores. All correlations on pre- and post-tests over r = .200 included.

	Reliability and Discrimination						Discrimination and Reliability			
	Pre-test		Post-test		Difference		Pre-test		Post-test	
	R*	D**	R	D	D	R	D	R	D	R
English	.252	.286	.270	.416	.04	.04				.209
Reading	.259	.347	.352	.327	.10	-.04				.292
Verbal	.360	.231	.380	.218	.01	-.06				.205
Arithmetic		.348			.07	.06			.204	.319
Total	.205	.280	.315	.285	.07	.02		.246		.276

* Reliability Program
** Discrimination Program

Table 23

Number of students preferring feedback or no feedback with mean level of stated preference and standard deviation

	Feedback			No Feedback		
	N	Mean	S.D.	N	Mean	S.D.
Group 1	51	4.02	.92	7	3.86	.64
Group 2	49	4.14	.90	7	2.86	1.25
Group 3	53	4.17	.88	5	2.60	1.36
Group 4	53	4.09	1.07	8	2.75	1.39
Total	206			27		

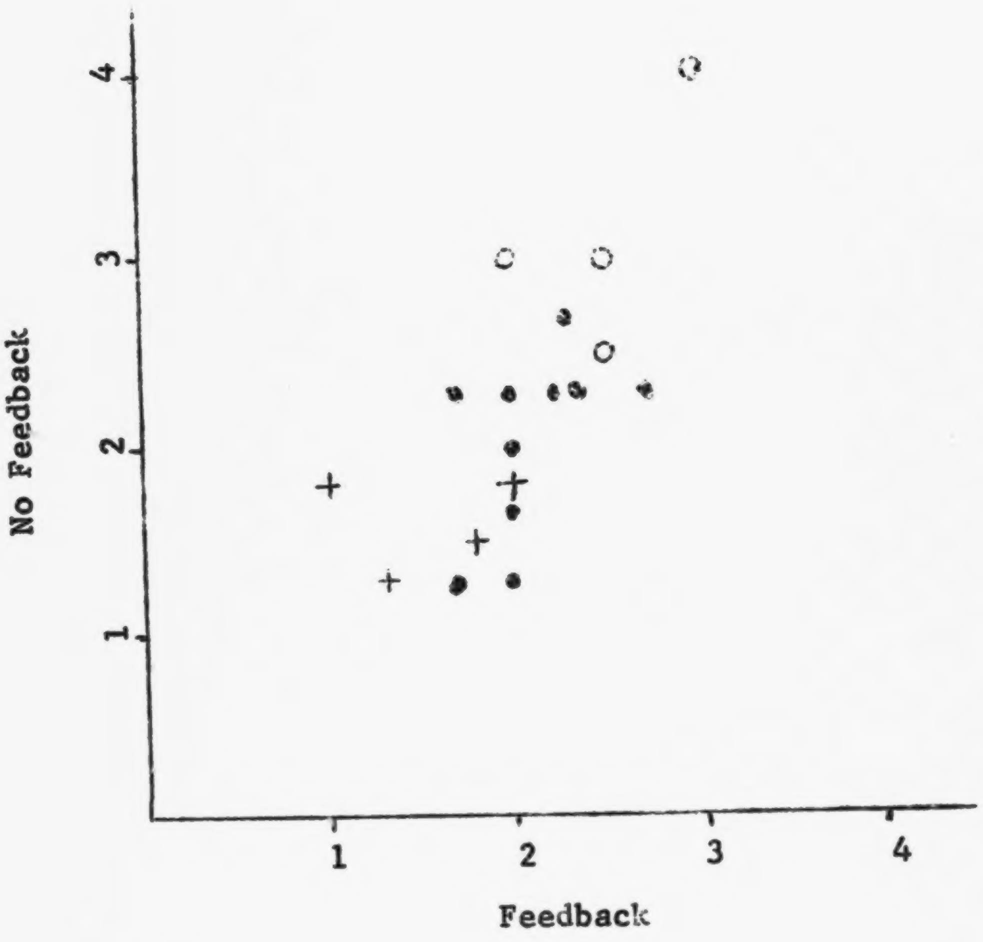

Figure 2. A scattergram of subjects whose pre-test scores under both feedback and no-feedback conditions were identical. Measures along axes are post-test scores divided by pre-test scores. Three groups of subjects are shown: 1) Pre-test scores of 2 (open circle); 2) Pre-test scores of 3 (closed circle); and 3) Pre-test scores of 4 (cross).

DISCUSSION AND CONCLUSIONS

Individual differences commonly arise from either of two sources: (1) prior learning or (2) basic abilities. It is widely recognized that both sources of individual differences may be significant for the specification of different modes of instruction. Psychologists differ in the relative emphasis they have placed on the importance of abilities vs prior learning for individualizing instruction. Gagne, we have already noted (p. 8-9), considers prior learning and "learning sets" to be of the utmost importance. Stolurow (1966) has tended to stress differences in aptitude or specific ability.

The present study lends almost no support at all to Stolurow's contention that we can use specific ability measures to help identify the best teaching mode for a given student.[3] It may be that ability measures can be used for this purpose, but this study provides no evidence to support the argument. Obviously, the present study may not have measured the "right" individual differences or provided the "right" instructional options to elicit the predicted effects.

With respect to the individual differences measured, it may be that Jensen's (1960) assertion that individual learning differences (by which he presumably means differences in drive strength, inhibition, susceptibility to interference, etc.) may be the really critical variables. It can also be argued that more basic psychological factors should have been measured in this study, e.g., Guilford's divergent-convergent thinking, and this, of course, is not an unreasonable suggestion. But, given Gagne's analysis of the problem (1962) one suspects that Guilford's basic factors would contribute most significantly to more primitive "learning sets" than those which were presumably required of Ss in the present study.

With respect to the instructional options employed in this, and similar studies for that matter, there is much to be said. First, the options used, e.g., overt response-covert response, feedback-no feedback, etc, may not have been sufficiently unique to elicit differential effects. Completely different instructional approaches would presumably be more apt to lead to these effects. Thus, in a study such as Porter's (1961) comparing such diverse instructional modes as programed and conventional instruction, one would be more apt to get a difference in effect than when the variable manipulated is, say, multiple choice vs constructed response. And Porter, as a matter of fact, did find that low IQ children benefited most from programed instruction.

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[3] See, for example, Stolurow (1962) where he states, "Our data, if supported by other findings, suggest that one way to individualize instruction would be to sequence a set in such a way as to make maximum use of the individual's abilities. With a computer based teaching machine, for example, the steps of the program could be stored and each student could then read into the machine his ability profile" (p. 352). For a more detailed discussion of this approach see Stolurow (1966).

Second, there is a broader point to be made and this point may come closer to the heart of the matter. In programed instruction, a given independent variable may be defined in widely different ways. Obviously, in the final analysis, the experimental situation defines the independent variable manipulated. But any impartial review of the literature of programed instruction reveals that experimenters mean very different things when they employ precisely the same terms to describe their experimental conditions. This means that it is extremely difficult (if not impossible) to make valid generalizations across different studies on the basis of the concepts used. This is even more serious when these generalizations are based on studies selected to support a particular thesis.

Annet's (1964) excellent analysis of the role of the knowledge of results (KR) concept in learning makes the point. Sometimes the KR concept means one thing and sometimes it means another. Annet distinguishes, for example, the motivational from the informational function of KR. KR as a matter of fact, may even reside in the structure of a frame. Moore and Smith (1961) have demonstrated that KR not only follows a frame, it generally precedes (and cues) the next. When this happens, KR may not only be unnecessary, it may actually interfere with learning.

The same general points can be made with respect to step size or covert vs overt responding, etc. Depending on the definition of these variables, one would expect very different results when they are experimentally manipulated. When one adds to this, the fact that studies in programed instruction have used Ss of all ages and employed very different subject matter, it is little wonder that the results are so conflicting.

It would, therefore, be pointless to attempt to generalize too far beyond the immediate data and conditions of this study. Nevertheless, it should be noted that, for the reasons stated, we are not particularly optimistic about research in this area. Along with a number of psychologists, we question the utility of measures of general intelligence for prescribing programed instruction conditions. But, we would go beyond this. At least, for the conditions of this experiment and the population studied, a number of other more specific ability measures appear to be of questionable value.

What are the implications of these observations for computer aided instruction? Given limited resources, it now appears to us that future research might better emphasize individual differences resulting from such factors as prior conditioning, transfer, and learning sets. Along with Gagne, we would shift our attention to a careful analysis of tasks, their sequencing, and the transfer of learning within sequences. This suggests computer programs which carefully assess relevant entry behavior (content) and rely on an analysis of performance within a programed sequence for the prescription of instructional modes rather than on measures of ability.

Summary

Two experiments were conducted to study the interaction of individual ability and attitude differences with programed instruction. Individual differences included: (a) tests of information, verbal, mathematical, reading, and general ability; (b) attitudes toward instructional methods and learning; (c) attitudes toward mathematics (the course taught in one of the two studies); (d) vocational interest; and (e) three other ability measures. The parameters of programed instruction manipulated were: (a) overt vs covert responding; (b) choice of instructional treatments vs no choice; (c) constructed response vs multiple choice; (d) preference vs no preference for feedback; and (e) feedback vs no feedback.

For the conditions and population of this study, at least, ability measures had almost no relationship to educational treatments and appear to be of questionable value for prescribing instructional treatments for individual students. With respect to CAI, it may be more profitable to develop programs which assess entry behaviors and which analyze performance within a programed sequence for the prescription of instructional modes rather than attempt to use measures of specific abilities or aptitudes for this purpose.

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Appendix A

Attitude Toward Learning Survey

Questions From the Attitudes Toward Learning Survey

Numbers in parentheses (1-5) indicate common factor loading (see text).

1. I prefer multiple-choice tests to essay exams. (1)
2. I learn best by working closely and directly with a teacher. (2)
3. I do not have very much mechanical aptitude. (1)
4. I like to figure out how to do a thing by myself rather than be told. (4)
5. I feel very uncomfortable when others know that I have made a mistake. (4)
6. I do not have to have things repeated over and over again for me to learn them. (5)
7. I have a good memory. (5)
8. With very little effort I could have achieved better grades in high school. (5)
9. I prefer to decide for myself how I will go about learning something new. (4)
10. I like it when I find out immediately where I have made my mistakes. (3)
11. I have never liked to participate directly in classroom projects. (3)
12. By the time I have read a chapter through once, I have generally learned the important points and ideas on which I will later be tested. (5)
13. Students are being treated more and more like IBM cards. (3)
14. I get mad when teachers fail to hand back a test paper until several days after the test. (2)
15. I prefer to plan my own study schedule rather than have someone else lay it all out for me. (-)
16. I like to take detailed notes when I'm trying to learn something new. (-)
17. I don't really require the "big picture" in order to learn the details. (5)
18. I do best when someone else sets the learning pace and I can follow their lead. (-)
19. Whenever I have to operate a machine, I become nervous. (1)

20. I prefer to have people tell me what they want me to do then leave me alone to do it. (4)

21. I don't like frequent exams in a course. (3)

22. I learn slowly. (5)

23. Machines can never change the fundamental nature of man. (2)

24. I learn best by doing. (3)

25. It is a teacher's responsibility to see to it that I learn the subject matter of a course. (-)

26. I don't like to have my errors pointed out to me. (3)

27. I like to know where I stand in a course at all times. (3)

28. There are as many opportunities to form close personal friendships today as in the past. (3)

29. I prefer to study a particular course at a regularly scheduled time rather than vary the time to fit my needs and inclinations. (-)

30. I generally make very few errors when learning something new. (-)

31. No matter how disorganized the teacher, I can usually make sense out of what he says. (-)

32. I find it difficult to learn something entirely new. (5)

33. I need more time than most students to learn something well. (5)

34. I learn best when someone "keeps me on the ball." (-)

35. I learn best when things are presented to me a small step at a time. (-)

36. When I'm learning a new subject, I like to skip around and let my interests lead the way rather than proceed through it on a step by step basis. (-)

37. I learn best when I'm on my own. (-)

38. If ideas are not presented in a well organized fashion, I have great trouble understanding them. (-)

39. I enjoy working with mechanical gadgets of all kinds. (1)

40. I enjoy learning new things. (3)

41. I learn best when I am not pressed for time. (-)

42. I prefer to figure things out for myself. (-)

43. The ideal learning situation involves one student and one teacher. (2)

44. I like the idea of a teacher standing by to give me help whenever I feel I need it. (2)

45. I learn best in a group situation where others are also learning. (-)

Appendix B

Demonstration Unit—Mathematics 082

Appendix B

Demonstration Unit-Mathematics 082

Introduction

1. You are about to take a course in basic Algebra. The course will be taught by machine, and in this sense, it may be different from any other course you have ever taken.

   You, of course, are primarily interested in learning some elementary mathematics as quickly as possible. We want to help you do this. In addition, we would like to find out how people learn under real life conditions. This knowledge about how people learn should help you to learn better. Push button A.

2. The materials are designed especially so that you will be able to do the work on your own. Push button A.

3. Hi. I am a teaching machine. In this class, we are going to teach the basic ideas of algebra--and we will try to remember that it can be fun. If you have questions or comments, the Instructor will be very, very happy to help. Now press the button marked "A" on the left.

4. I am a fairly easy machine to use--when I work right. There are three buttons on the left, A, B, and C. Throughout this program, if no other instructions are given at the end of a frame, press button A. Sometimes, you will have a multiple-choice frame and will have to choose one of the buttons. Like this:

   Press button A if you want to stop here.

   Press button B if you want to go on.

   Press button C if you don't think this is worth it.

   4A. Aw! Come on, press B.

4C. You're making me feel bad. You don't think I can teach. C'mon press B.

5. Good! I am glad to see you think we are worth trying. Remember, like Avis we try harder. Now press A.

6. The material you will study on the teaching machine is called a program. A program is divided into frames. Each frame covers a small bit of information. Push button A and move to the next frame.

7. Frames are combined to form units. There are about 60 units in the Math 082 ____________. Push button A after you have thought of an answer.

Answer to 7: program.

8. In the last frame you were expected to fill in the blank or add the missing _______. Frames of this kind call for a constructed response. Push button A.

Answer to 8: word.

9. A constructed response is different from a multiple-choice response. In the constructed response the student must make up the response, whereas in the _________ ___________ response the student merely selects the correct response from several alternatives. Push button A.

Answer to 9: multiple-choice.

10. The previous frame called for a ___________ response. Let's try an example of a multiple-choice frame. Push button A.

Answer to 10: constructed.

11. You are about to study a course in basic mathematics. This course places the major responsibility for learning the subject matter on:

A. The teacher

B. The student

C. The machine

11. A. No. In this course you will rarely see or talk to a teacher. Go to B.

11. C. Wrong. The machine can only provide the opportunity for you to learn. Go to B.

11. B. Correct. In the final analysis the responsibility for learning this material rests with you.

12. You will note that after answering either a multiple-choice item or a constructed response item, you were given the correct answer.

13. When the program supplies you with information about the correctness of your answer or tells you why you are wrong, this is called knowledge of results. Since you will be required to respond to this frame, you will get ________ of ____________ after you have supplied the correct answer and pushed Button A.

Answer to 13: Knowledge of results.

14. There are _____ inches in a yard.

Answer to 14: 36 inches. (This is an example of knowledge of results)

15. Knowledge of _______________ may also be provided to a student after he has answered a multiple-choice frame to tell him whether or not he had selected the correct answer. From now on push button A to move forward in the program.

Answer to 15: results

16. Sometimes a student is expected to write out the answer to an item. At other times, he may merely be expected to say the answer to himself. A student may write out the answer to a ________________ choice question as well as to a constructed response question. (Please write your answer on the answer paper.)

Answer to 16: multiple

1. Number Theory

Note to Student: The next three frames illustrate constructed response (fill in or completion items). After you write down the answer on the answer paper, you may check your response by pressing button A.

1. The "kind" of numbers which we are going to study first are the natural numbers. The natural numbers are the numbers used for counting: 1, 2, 3, 4...are natural numbers.

18 is a ___________ number.

Answer to 1: natural

2. Number theory is the part of mathematics which deals with the properties of natural numbers. One property of a natural number is the number of factors it has.

3 x 5 = 15. This means that 3 is a factor of 15 and 5 is a factor of 15.

1 x 15 = 15. This means that ________ is a factor of 15 and __________ is a factor of 15.

Answer to 2: 1, 15

3. 10 x 6 = 60. Therefore, 10 and 6 are factors of 60. 10 and 6 are also called divisors of 60. (10 and 6 are said to divide 60.)

The divisors of 12 are ____, ____, ____, ____, ____, ____?

Answers to 3: 1, 2, 3, 4, 6, and 12.

Note to Student: The next eight parts illustrate multiple-choice items. Instead of writing your answer down, say it to yourself. Then check your answer by pressing button A, B, or C.

4. The first few multiples of 10 are 0, 10, 20, 30, 40, 50. (Note: 0 x 10 = 0) What is the next larger multiple of 10?

A. 100 B. 60 C. 40

4 A. Sorry, 10 x 10 = 100 but the next multiple of 10 after 50 is 60.

4 C. Oh, come now, 40 is the multiple of 10 before 50.

4 B. Correct. The next larger multiple of 10, following 50, is 60.

5. The first 10 multiples of 6 are: 0, 6, 12, 18, 24, 30, 36, 42, 48, 54. What is the next larger multiple of 6?

A. 60 B. 66 C. 58

Answer to 5: A is correct. The next larger multiple of 6 after 54 is 60.

6. Which ones are all multiples of 5?

A. 1, 5 B. 0, 5, 10, 15, 20, 25 C. 0, 1, 2, 3, 4, 5

6 A. Nope, 1 is surely not a multiple though it may be a factor of 5.

6 C. Think! This can't be it!

6 B. Yes. Some multiples of 5 are 0, 5, 10, 15, 20, 25.........

7. 48 is a multiple of 8 because there is another number (6) such that 8 times 6 is 48. 6 x 8 = 48. Is 27 a multiple of 9?

A. Yes B. No

Answer to 7: A. 27 is a multiple of 9. 3 x 9 = 27.

8. 4 x 5 = 20

4 is a factor of 20
5 is a factor of 20

20 is a multiple of 4
20 is a multiple of 5

Complete this statement: 20 is a ________ of 5, therefore 5 is a ____________ of 20.

A. Multiple, factor B. Factor, multiple

Answer to 8: A is correct. 20 is a multiple of 5, therefore, 5 is a factor of 20.

9. One natural number (for example, 4) is a factor of a second natural number (for example, 20) if the second (that is, 20) is a multiple of the first (that is, 4). Is 9 a factor of 52?

A. Yes B. No

Answer to 9: B. 9 is not a factor of 52 because there is not a natural number which, when multipled by 9, gives 52 as the product.

10. The multiples of 1 are ________________.

A. All numbers except 1. B. All natural numbers

10 A. Nope! 1 is a multiple of 1: 1 x 1 = 1

Answer to 10: B. 1 x 0 = 0; 1 x 1 = 1; 1 x 2 = 2...thus every natural number is a multiple of 1.

11. Every number except one (1) has at least __________ distinct factor(s).

A. 1 B. 2 C. 3

Answer to 11: B. Every number except one (1) has at least 2 distinct factors.

Note to Student: The next five frames illustrate both constructed response and multiple-choice frames where you do not write out the answer but say it to yourself. To check you answer, push button A, B, or C.

12. List all the factors of 5.

Answer to 12: 1, 5.

13. A number that has 2 and only 2 factors is called a prime. Is 6 a prime?

A. 6 is a prime B. 6 is not a prime

Answer to 13: B. 6 is not a prime; it has more than 2 factors.

14. Since number 1 has only one factor, itself, it is/is not a prime?

A. Is B. Is not

Answer to 14: B. 1 is not a prime. It has only one factor.

15. The first five primes are 2, 3, 5, 7, 11. The next prime is __________.

Answer to 15: 13 (its only factors are 13 and 1).

16. 8 has the factors ____, ____, ____, and ____.

Answer to 16: 1, 2, 4, 8.

Note to Student: The next 8 frames illustrate multiple-choice items where you must write down the answer (that is, the word(s) or numbers, not the letter A, B, or C) on the answer sheet before you check your answer.

17. If a number has more than two distinct factors and all of its factors can be written down, it is called a composite number. The latter criterion prevents 0 from being a composite number since every number is a factor of 0, and we cannot write down every natural number, can we?

8 is a ____________ number.

A. natural B. composite C. Both A and B

17 A. Yes, it's natural, but that isn't all! Try again.

17 B. Well, that's true, but is it the best answer?

Answer to 17: C. 8 is both a composite number and natural number.

18. The number 0 is __________________.

A. Composite number B. Not a composite C. A prime number

Answer to 18: B. It is not composite, because you cannot write down all the factors of 0.

19. 1 is a composite number.

A. True B. False

19 A. Nope, Composite numbers must have more than two factors. How many does 1 have?

Answer to 19: B. 1 is not a composite number, because it does not have more than two factors.

20. Every number except 0 or 1 is either a prime number or a composite number.

4 is a ____________ number.

A. Composite B. Prime

Answer to 20. A. 4 is a composite number. It has more than two factors.

21. 0, 2, 4, 6, 8 are the first five even numbers. The next even number is ______________.

A. 9 B. 10 C. 11

Answer to 21: B. 10 is the next even number after 8.

22. A number is called even if it is a ___________ of 2.

A. Multiple B. Divisor C. Neither

Answer to 22: A is right. A number is called even if it is a multiple of 2.

23. 1, 3, 5, 7, are the first four odd numbers. The next odd number is _____________.

A. 8 B. 9 C. 10

Answer to 23: B. The next odd number after 7 is 9.

24. A number is odd if it is not a _______________ of 2.

A. composite B. factor C. multiple

Answer to 24: C. A number is odd if it is not a multiple of 2.

Note to Student: For the next eight frames, say the answer to yourself. Check your answer by pressing button A. Some of these frames are multiple-choice and the others are constructed response.

25. Which of the following numbers are even?

1) 5,756,742; 2) 20,725; 3) 1071; 4) 5726; 5) 648

Answer to 25: 1) 5,756,742
4) 5726
5) 648

26. An easy way to tell if a number is even is to look at the last digit. If the last digit is ___________, the number is even. If the last digit is ___________, the number is odd.

A. even, odd. B. odd, even

Answer to 26: A. even, odd. If the last digit is even, the number is even. If the last digit is odd, the number is odd.

27. 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36 are multiples of 3. They are, therefore, divisible by 3. Do you see a peculiarity about the sum of the digits of each of these numbers? For example, the sum of the digits of:

3 is 3
12 is 1 + 2 = 3
21 is 2 + 1 = 3
30 is 3 + 0 = 3

6 is 6
15 is 1 + 5 = 6
24 is 2 + 4 = 6
33 is 3 + 3 = 6

9 is 9
18 is 1 + 8 = 9
27 is 2 + 7 = 9
36 is 3 + 6 = 9

Answer to 27: The sum of the digits of these multiples of 3 is 3, 6, or 9.

28. The next bigger multiple of 3 is 39. 3 + 9 = 12, but 1 + 2 = 3. Can you guess at some property of the numbers divisible by 3?

Answer to 28: I wanted you to guess that "A number is divisible by 3 if the sum of its digits is divisible by 3."

Note to Student: Sometimes you will find frames like the next three. They do not require an answer, but you must read them carefully to learn how to solve such problems.

29. Is the number 2748 divisible by 3?

$2 + 7 + 4 + 8 = 21$ $\quad$ $2 + 1 = 3$ $\quad$ 2748 is divisible by 3.

So is 7248, 4728, etc.....

30. In the problem above, you might have reasoned in the following way:

2748 is divisible by 3 if the sum of its digits is divisible by 3. The sum of its digits is 21. But 21 is divisible by 3 if the sum of its digits is divisible by 3. $2 + 1 = 3$, therefore, 21 is divisible by 3. Therefore, 2748 is divisible by 3.

Is the natural number 2,759,367 divisible by 3?
$2 + 7 + 5 + 9 + 3 + 6 + 7 = 39$

$3 + 9 = 12.$ $\ 1 + 2 = 3$

31. Now we ask if the converse is true. That is, if the sum of the digits of a number is not divisible by 3, does this mean that the number is not divisible by 3.

Is 1271 divisible by 3?

$$\begin{array}{r} 423 \\ 3\overline{)1271} \\ \underline{12} \\ 7 \\ \underline{6} \\ 11 \\ \underline{9} \end{array} \quad + 2 \text{ remainder}$$

Answer to 31: 1271 is not divisible by 3.
$1 + 2 + 7 + 1 = 11$
11 is not divisible by 3.

32. It is true that, "if the sum of the digits of a number is not divisible by 3, then the number is not divisible by 3." Which of the following is divisible by 3?

A. 62 $\qquad$ B. 2,725,365 $\qquad$ C. 972,365

Answer to 32: B. 2,725,365

Congratulations!

You have finished Unit 1. Please tell the instructor. If you have more time today, he'll give you another unit of about the same length.

Appendix C

Mathematics 082

Mid-term Examination

MATHEMATICS 082
(Section I)

MID-TERM EXAMINATION

NOVEMBER 1966

NOTE TO STUDENTS: This test is in two parts. The first part is objective and the second, short answer. You will use IBM sheets for the first part and fill in the blanks on these forms for the second. Your score will be posted after all the tests have been graded. You will be given a copy of this test with the correct answers sometime later.

PART I - OBJECTIVE

Fill in your name, student number, and date on the IBM sheet accompanying this test. Black in the best answer for multiple choice items. For True-False items (1) is True, (2) is False.

1. A number that has more than 2 factors is called a prime. (1) True, (2) False.

2. Given the statement $17 + 35 = X$, a number that replaces X and makes the statement true is called the (1) solution set, (2) solution, (3) terminal value, (4) augend.

3. Given the mathematical statement $8x + 4 = 4$. 8 is a (1) variable, (2) operator, (3) numeral, (4) place holder.

4. The multiplicative identity is (1) 0, (2) 1.

5. Which of the following is a prime number. (1) 8, (2) 9, (3) 10, (4) All of these, (5) None of these.

6. If $X + 27 = 43$, what is the value of X? (1) 70, (2) -70, (3) 16, (4) -16.

7. $X + 6 = 32$ is (1) Open, (2) Closed.

8. If you add 7 to the left side of an equation, what must you do to the right side? (1) leave it alone, (2) add -7, (3) add 7.

9. Which of the following is an application of the Commutative Law for Addition? (1) $2 + 3 = 3 + 2$, (2) $2 + (2 + 3) = (2 + 2) + 3$, (3) Neither 1 nor 2, (4) Both 1 and 2.

10. $5 \cdot 0 = ?$ (1) 5, (2) 0, (3) 1, (4) None of these.

11. A set of picture frames is constructed, each 3 + X units long and 5 units wide. What is the area enclosed by any frame? (1) 15 + 5x, (2) 8 + x, (3) 8 + 5x, (4) 15 + x.

12. Which of the following is a prime number? (1) 37, (2) 38, (3) 39, (4) 40.

13. Which of the following is an odd number? (1) 10, (2) 32, (3) 146, (4) 3464, (5) None of these.

14. Which of the following is NOT an equation? (1) R + 8 = 7, (2) 2 + 3 - 7, (3) 8 · 4 = 32, (4) 0 = 0.

15. What is the product of 12 and 13? (1) 156, (2) 25, (c) $\frac{12}{13}$, (4) 1213.

16. Given the mathematical statement 8X ÷ 4 = 4, the ÷ sign is a (1) variable, (2) operator, (3) numeral, (4) place holder.

17. If 4B + 3 = 9, B = _________? (1) $\frac{27}{4}$, (2) $\frac{4}{27}$, (3) $\frac{2}{3}$, (4) $\frac{3}{2}$.

18. Which of the following is an application of the Associative Law for Addition? (1) 2 + 3 = 3 + 2, (2) 2 + (2 + 3) = (2 + 2) + 3, (3) Neither 1 nor 2, (4) Both 1 and 2.

19. A number times its reciprocal = ? (1) 0, (2) The number itself, (3) 1, (4) a fraction, (5) none of these.

20. One may convert the expression (13 · 2) + (7 · 2) into (13 + 7) · 2 by taking advantage of the ____________ law of multiplication and addition. (1) Commutative, (2) Associative, (3) Distributive, (4) Identity.

21. There is exactly one prime number which is also an even number. (1) True, (2) False.

22. If 16 > X > Y then (1) X is a larger number than 16, (2) Y is a larger number than 16, (3) Both 1 and 2 are true, (4) Neither 1 nor 2 is true.

23. The immediate successor of the integer - 27 is _________. (1) -28, (2) -26, (3) 26, (4) 28.

24. Given two numbers on a number line, their average lies (1) to the left of the smaller number, (2) to the right of the larger number, (3) between the two numbers, (4) any of these, depending on the particualr numbers.

25. A rational number is one that can be expressed as the __________ of two integers. (1) sum, (2) difference, (3) product, (4) quotient.

26. A number is divisible by 3 only if the sum of its digits is divisible by (1) 1, (2) 2, (3) 3, (4) 5, (5) None of these.

27. Which of the following can be used to check the addition $49 + 50 = 99$? (1) $99 - 50 = 49$, (2) $99 - 49 = 50$, (3) Both 1 and 2, (4) Neither 1 nor 2.

28. Given the mathematical statement $8X \div 4 = 4$, X is a (1) variable, (2) operator, (3) numeral, (4) place holder.

29. Since subtraction is the inverse of addition, subtraction is also commutative. (1) True, (2) False.

30. Which of the following are the prime factors of 36? (1) $12 \cdot 3$, (2) $9 \cdot 4$, (3) $6 \cdot 6$, (4) None of the above.

31. The greatest common divisor of a set of numbers is defined to be their ________________ common factor. (1) unique, (2) smallest, (3) largest, (4) prime.

32. Given an integer N. The immediate predecessor of N plus the immediate successor of N gives the result. (1) 0, (2) N, (3) 2N, (4) $N^2 - 1$.

33. Which of the following is necessary to insure that $a < \frac{1}{2}(a + b)$? (1) $a < b$, (2) $a > b$, (3) $a = b$, (4) any of these.

34. Express $\frac{22}{7}$ as a decimal number. (1) 3-1/7, (2) 3.142857, (3) $3.\overline{142857}$, (4) π.

35. Multiplication is both associative and commutative. (1) True, (2) False.

36. Which of the following pairs are said to be relatively prime? (1) 15, 6, (2) 14, 7, (3) 16, 6, (4) 16, 9.

37. Which of the following does NOT represent an integer? (1) $\frac{12}{2}$, (2) $\frac{12}{3}$, (3) $\frac{12}{4}$, (4) $\frac{12}{5}$.

38. To check a division problem we (1) multiply dividend by quotient and add remainder to get divisor, (2) multiply divisor by remainder and add dividend to get quotient, (3) multiply divisor by dividend and add quotient to get remainder, (4) multiply divisor by quotient and add remainder to get dividend.

39. A - (-B) = (1) A - B, (2) A + B.

40. (-B) + A = (1) A - B, (2) B - A.

41. A positive number divided by a positive number is a positive number. (1) True, (2) False.

42. The product of 2 numbers with the same sign is a positive number. (1) True, (2) False.

Match column A to column B:

	A	B
43.	Commutative Law	(1) 1
44.	Distributive Law	(2) a + b = b + a
45.	Associative Law	(3) 0
46.	Additive Identity	(4) a (bc) = (ab) c
47.	Multiplicative Identity	(5) c (a + b) = ac + bc

PART II - FILL IN

48. Find the greatest common divisor of 91 and 208 (Hint: Use Euclid's Method). __________

49. Express $.\overline{8}$ as a rational fraction: __________

50. A number may be represented by one and only one symbol. (True or False.) __________

51. Given that Y + 13 = 13, Y = ______. __________

52. The square root of 81 is either +9 or _____. __________

53. The reciprocal of 5 is ______. __________

54. If $\frac{2}{3}$ Y + 1 = Y, then Y = ______. __________

55. Write the number consisting of 5 ones, 8 hundreds, 2 thousands, 3 tens. __________

56. What do we use to represent a "place holder" for empty columns. __________

57. The length of a rectangle is 4 times its width. If you represent the width with w, how do you represent the length? __________

58. Find the least common multiples of 10, 15. __________

59. A sentence is open if it contains one or more __________. __________

60. What number is represented by the following:

```
X X X 0
X X X
X X X
X X X
X   X
X   X
```

____

61. There is a number N such that 3 times N is 2 more than N. N = ________? __________

62. If $\frac{12}{x} = 2.71828$, then 2.71828 x = ________? __________

63. Find the least common multiples of 13, 7. __________

64. Express the sum of 3 times a certain number N and 8 times the same number. __________

65. Find the least common multipes of 0, 5. __________

66. What number consists of 6 sets of 200 and 4 sets of 1? __________

67. Joe and Joan tried to see how many football tickets they could buy in their respective dorms for resale to non-MSU students. Joe got 5 more than twice as many as Joan. Together they got 47 tickets. Using X for the unknown, what formula would you use to solve this problem? __________

68. One of two numbers is twice as large as the other. The sum of the numbers is 312. What is the smaller number? __________

Add the bottom and top numbers:

69. $\begin{array}{r} +27 \\ \underline{-18} \end{array}$ __________

70. $\begin{array}{r} -29 \\ \underline{+13} \end{array}$ __________

71. $\begin{array}{r} -77 \\ \underline{+59} \end{array}$ __________

72. $\begin{array}{r} -32 \\ \underline{+17} \end{array}$ __________

Subtract the bottom number from the top number:

73. $\begin{array}{r} -23 \\ \underline{+17} \end{array}$ __________

74. $\begin{array}{r} +57 \\ \underline{-19} \end{array}$ __________

75. $\begin{array}{r} -17 \\ \underline{-17} \end{array}$ __________

76. $\begin{array}{r} +27 \\ \underline{-19} \end{array}$ __________

Multiply:

77. $(-6) \times (+7)$ __________

78. $(+4) \times (-2)$ __________

79. $(-4)\ (+2)\ (+3)\ (+2)$ __________

Divide:

80. $(+12) \div (-2)$ __________

81. $(-14) \div (+7)$ __________

82. $(-25) \div (+5)$ __________

Find the square:

83. $(10^2)^2$ __________

84. $(3-3/5)^2$ __________

85. $(12/5)^2$ ____________

Find the Square Root:

86. $\sqrt{900}$ ____________

87. $\sqrt{4}$ ____________

88. $\sqrt{16}$ ____________

89. If a is greater than b, then b is ______ than a. ____________

90. A positive times a negative is a _______. ____________

91. Subtracting a positive number is the same as adding a ______ number. ____________

92. The product of two negative numbers is a _____________ number. ____________

Write "greater than" relations for the following pairs of numbers:

93. (56 133) ____________

94. (17 -21) ____________

95. (-3 -9) ____________

96. (-6 0) ____________

97. Given that $8 - x = 7$, $x =$ ____________? ____________

Appendix D

Mathematics 082

Final Examination

MATHEMATICS 082
(Section I)

FINAL EXAMINATION

DECEMBER 1966

NOTE TO STUDENTS: This test is in two parts. The first part is objective and the second, short answer. You will use IBM sheets for the first part and fill in the blanks on these forms for the second. Your score will be posted after all the tests have been graded. You will be given a copy of this test with the correct answers sometime later.

PART I - OBJECTIVE

Fill in your name, student number, and date on the IBM sheet accompanying this test. Black in the best answer.

1. Given set notation, the equation for "S equals all X such that X is greater than 15 and less than 30" would be written:
   - (1) $S = \{X \supset 15 \angle X \angle 30\}$
   - (2) $S = \{X \cup 15 \geq X \angle 30\}$
   - (3) $S = \{X | 15 \angle X \angle 30\}$
   - (4) $S = \{X | 15 \geq X \angle 30\}$

2. Given two sets $A = \{1, 7, 9, 11\}$ and $B = \{2, 4, 7, 9, 10\}$. The equation for the union of A and B is:
   - (1) $A \cup B = \{7, 9\}$
   - (2) $A \cup B = \{1, 2, 4, 7, 9, 10, 11\}$
   - (3) $A \cap B = \{1, 2, 4, 10, 11\}$
   - (4) $A \cap B = \{1, 2, 4, 7, 9, 10, 11\}$

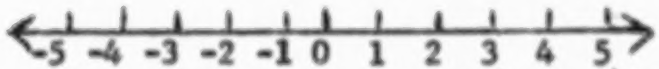
3. Given two sets $A = \{2, 4, 6, 8, 10\}$ and $B = \{6, 10\}$. The equation for the intersection of A and B is:
   - (1) $A \cap B = \{6, 10\}$
   - (2) $A \cup B = \{6, 10\}$
   - (3) $A \cap B = \{2, 4, 8\}$
   - (4) $A \cup B = \{2, 4, 8, 10\}$
   - (5) $A \cup B = \{2, 4, 6, 8, 10\}$

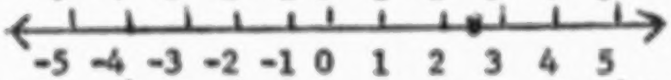
4. If $A = \{1, 5, 9\}$ and $B = \{3, 7\}$ then $A \subseteq B$.
   (1) True (2) False

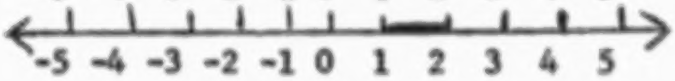
5. When we say the solution set for a given equation is empty, we mean the equation has ______________.

   (1) no solution.
   (2) zero as its only solution
   (3) an infinite number of solutions

6. Which of the following graphs shows the solution set of $2X + 3 = 8$?

   (1)


   (2)


   (3)


   (4) none of these

7. Assuming an X - Y grid placed on a street map, the ordered pair for +13 North-South and -6 East-West would be written: (1) 13,-6 (2) -13, 6 (3) -6, 13 (4) -6, -13

8. The X-axis and Y-axis divide the Cartesian coordinate system into four parts, called quadrants. The quadrant covering from 180 degrees to 270 degrees is called?

   (1) Quadrant I (2) Quadrant II (3) Quadrant III (4) Quadrant IV

9. Which of the following is not a linear form? (1) $X + Y$ (2) $5X + \frac{3}{7Y} + \frac{1}{2}$ (3) $\frac{2}{3X} + 4Y + 3$ (4) $3X^2 + \frac{1}{2Y} + \frac{2}{3}$

10. Given the linear equation $2X + 2Y - 4 = 0$, if X is 1, Y is: (1) 1 (2) 2 (3) 3 (4) -4

11. The graph of a linear equation is best described as a (1) Curve (2) Circle (3) Hyperbole (4) Straight line

12. In order to plot a linear equation one must know at least _______ points on the Cartesian coordinate system. (1) 1 (2) 2 (3) 3 (4) 4 (5) 5

13. For the system of linear equations $\begin{cases} x = 4 \\ y = 6 \end{cases}$ the solution set would be ____ ________.

    (1) $\{(4, 6)\}$ (2) $\{(6, 4)\}$ (3) either of these (4) neither of these

14. A propeller-aircraft traveling 300 m.p.h. left the airport at 7 a.m. and a prop-jet traveling 500 m.p.h. in the same direction left the airport at 9 a.m. At what time does the second overtake the first?

(1) 11 a.m. (2) 12 noon (3) 1 p.m. (4) 2 p.m.

15. The absolute value of a number X is written $|X|$ and obtained by assigning a plus sign whatever the original sign of the number; thus $|2| = 2$, $|-3| = 3$, $|0| = 0$, etc. Given the system of equations $\begin{cases} |X| = 2 \\ |X| + Y = 3 \end{cases}$ the value of Y is ________.
(Hint: use method of substitution).

(1) 0 (2) 1 (3) 2 (4) 3

16. Given that $|x| = 4$ and $|y| = 4$, does it follow that $x = y$?

(1) Yes (2) No

17. What is the value of $\underline{N}$ that will make the system $\begin{cases} 3X + 2Y - 3 = 0 \\ 2X + \underline{N}y - 1 = 0 \end{cases}$

equivalent to the system $\begin{cases} 6X + 4Y - 6 = 0 \\ 6X + 3Y - 3 = 0 \end{cases}$?

(1) 1 (2) 2 (3) 3 (4) none of these

18. A chessboard has 8 rows and 8 columns of squares. The total number of squares on 8 chessboards is therefore ________.

(1) 8^3 (2) $3(8)^2$ (3) 8^{8^8} (4) 3^8

19. Computer X has 2^{16} individually addressable memory locations and computer Y has 2^{12}. Thus computer X has ____________ times as many such locations as computer Y.

(1) 2 (2) 4 (3) 8 (4) 16

20. $\dfrac{7^{-1} \cdot 7^2}{7^0} =$ ________?

(1) 0 (2) 7 (3) 49 (4) undefined

21. The set of all polynomials is a subset of the set of all monomials.

(1) True (2) False

22. $(-M^3)\ (-M^2) =$ ______________

(1) $-M^5$ (2) M^5 (3) $-M^6$ (4) M^6

23. $3(3a^3)^2 =$ ________________

(1) $9a^5$ (2) $27a^5$ (3) $9a^6$ (4) $27a^6$

24. $\frac{72^{300}}{72^{100}} =$ ___________

(1) 72 (2) 72^3 (3) 72^{200} (4) none of these

25. What is the result when -4 is substituted for k in $(x + k)^2$.

(1) $x^2 - 8x + 16$ (2) $x^2 - 8x - 16$

(3) $x^2 + 8x + 16$ (4) $x^2 + 8x - 16$

26. The factors of $2x^2 - 6x$ are:

(1) 2 (2) x (3) $(x - 3)$ (4) all of these

27. Which of the following is NOT a perfect square?

(1) $9x^2 + 6x + 1$ (2) $x^2 + 8x + 16$

(3) $x^2 - 4X + 4$ (4) $25x^2 - 10x - 1$

28. x^{3+2} may also be written:

(1) $(x^3)^2$ (2) $(x^3)\ (x^2)$ (3) $x^3 + x^2$

29. $|x| = \sqrt{x^2}$

(1) True (2) False

30. The only number below that is irrational is:

(1) $\sqrt{9}$ (2) $14\frac{1}{13}$ (3) $\sqrt{12}$ (4) 1.33

31. $\frac{5y + 4}{6y} + \frac{2y - 6}{3y} = ?$

(1) $\frac{18y - 12}{12y}$ (2) $\frac{27y - 24}{18y}$ (3) $\frac{3y - 2}{2y}$ (4) $\frac{9y - 8}{6y}$

32. $\left(\frac{a}{b} + 5\right) \div \left(\frac{a}{b} + 2\right) = ?$

(1) $\frac{(a + 7b)b}{a(a + b)}$ (2) $\frac{b(a + 5b)}{b(a + b)}$ (3) $\frac{a + 5b}{a + 2b}$ (4) $\frac{a + 5}{a + 2}$

33. When dividing one polynomial by another of lower degree, the degree of the remainder will be ________ the degree of the divisor.

(1) less than (2) greater than (3) equal to

34. $\frac{x^4}{x + 1} =$ ________?

(1) $x^3 + x^2 + x + 1 + \frac{1}{x + 1}$

(2) $x^3 - x^2 + x - 1 + \frac{1}{x + 1}$

(3) $x^3 + \frac{1}{x + 1}$

(4) $x^3 - \frac{1}{x + 1}$

35. Given that $-3x - 6 = 0$, the value of x is ______?

(1) -2 (2) +2 (3) 0 (4) indeterminate

36. Given that $\frac{x - 2}{x^2 + 4} = 0$, the value of x is ________?

(1) -2 (2) +2 (3) 0 (4) indeterminate

37. Odd-numbered roots of negative numbers (e.g., $\sqrt[3]{-28}$ or $\sqrt[9]{-104}$)

__________.

(1) are always negative. (2) may fail to exist.

38. $\sqrt{16} =$ _________?

(1) $\sqrt{4} \cdot \sqrt{4}$ (2) $\sqrt{8} \cdot \sqrt{2}$ (3) both of these (4)
(4) neither of these

39. Which of the following is the nearest approximation to $\sqrt{82}$?

(1) 7.1 (2) 8.1 (3) 9.1 (4) 10.1

40. $\sqrt{\frac{1}{4}} + \sqrt{\frac{1}{9}} =$ __________?

(1) $\frac{3}{2}$ (2) $\frac{2}{3}$ (3) $\frac{1}{6}$ (4) none of these

41. $3\sqrt{12} + 2\sqrt{27} + \sqrt{48} = 16\sqrt{3}$

(1) True (2) False

42. $(2\sqrt{5})(2\sqrt{7}) =$ ________?

(1) $2\sqrt{12}$ (2) $2\sqrt{35}$ (3) $4\sqrt{12}$ (4) $4\sqrt{35}$

43. $\sqrt[9]{x^{18}} =$ ________?

(1) x^9 (2) x^2 (3) x (4) $x^{\frac{1}{2}}$

44. $\sqrt{x - y} = \sqrt{x} - \sqrt{y}$

(1) always true (2) always false (3) Depends on value x & y

PART II - FILL IN

45. Write the set of all positive integers less than 4. __________

46. Using set notation write Z is a subset of X. __________

47. Given the equations $x^2 = 4$, the solution set has ______ members. __________

48. The __________ of a variable specifies all the numbers that may be used as replacements for the variable. __________

49. In the Cartesian coordinate system, the ordered pair (0, 0) is called the __________. __________

50. The X - coordinate is sometimes called the _____. __________

51. The Y - coordinate is sometimes called the _____. __________

52. Given the system of linear equations $\begin{cases} x + y = 4 \\ x = 4 \end{cases}$ the value of y in the solution set is __________. __________

53. Solving the system of equations $\begin{cases} x + y = 3 \\ 2x + y = 1 \end{cases}$

the value of x is ________. ____________

54. ________ is the negative of the linear form $2x - y + 3$. ____________

55. The sum of the digits of a two-digit number is 10. If the order of the digits is reversed, the original number is increased by 18. The original number must be ________. ____________

56. An expression of the form Kx^n appearing in a polynomial is called a ________. ____________

57. The numbers 9, 8, 7, 6, 5, in the polynomial $9x^4 + 8x^3 + 7_x2 + 6x + 5$ are called ________. ____________

58. If someone wrote out the meaning of $99y^{101}$, y would appear ______ times. ____________

59. $(2x)^2\ (x) =$ ________. ____________

60. $\dfrac{(-4K^2)^3}{4K} =$ ________? ____________

61. $(27 + 18s + 3s^2) \div (3s + 9) =$ ________? ____________

62. If $(6x + K)\ (6x - K) = 36x^2 - 81$, what is the value of K? ____________

63. What is the constant term in the expansion of $(2x - 5)^2$? ____________

64. Give a simpler form of $\left(\dfrac{x^3}{x^4}\right)^{-1}$ ____________

65. $\dfrac{3x + 3}{x - 4} \cdot \dfrac{2x - 8}{x + 1} = ?$ ____________

66. $\dfrac{2a - 4}{a^2 - 1} \div \dfrac{a^2 - 4}{a^2 + a - 2}$ ____________

67. $\dfrac{x - 2}{x + 5} - \dfrac{2x - 3}{x^2 + 6x + 5} = ?$ ____________

68. When dividing complex fractions, such as

$$\left(\frac{2x}{y} + \frac{y}{4}\right) \div \left(\frac{x^2}{y^2} - \frac{6}{x}\right)$$ the first step is:

Find the least common denominators and simplify the resulting expression. The next step is to find the ______ of the divisor. ____________

69. In finding the reduced form of the complex fraction, $\dfrac{\frac{2-b}{5}}{\frac{1}{a} + \frac{2}{ab}}$ you would multiply

both numerator and denominator of $\dfrac{\frac{2-b}{5}}{\frac{b+2}{ab}}$ by _____. ____________

70. The quotient of two polynomials in one variable is called a ________ algebraic expression. ____________

71. If the divisor of a polynomial in one variable is a factor of the ________, then the quotient is also a polynomial. ____________

72. What is the least common denominator for the expression on the left side of ____________

$$\frac{3}{x-3} + \frac{2}{x+3} - \frac{1}{x^2-9} = 0?$$

73. Express the fourth root of 59 using radical sign notation. ____________

74. Express the fifth root of 20 using exponent notation. ____________

75. $(\sqrt{3} + \sqrt{5})(\sqrt{3} - \sqrt{5}) =$ ____________

Evaluation services
raw score distributions

44 items on test 9500

December 1966

Raw Score	Frequency	Cumulative Frequency	Percentile Rank	Standard Score
41	1	1	99	74.4
39	4	5	98	70.1
38	3	8	96	67.9
37	1	9	95	65.7
36	9	18	92	63.6
35	12	30	86	61.4
34	7	37	80	59.2
33	15	52	73	57.0
32	5	57	67	54.9
31	10	67	63	52.7
30	16	83	55	50.5
29	15	98	45	48.5
28	20	118	35	46.3
27	11	129	26	44.1
26	10	139	19	42.0
25	5	144	15	39.8
24	6	150	11	37.6
23	5	155	8	35.5
22	5	160	5	33.3
21	2	162	3	31.1
20	2	164	2	29.0
18	1	165	1	24.6
17	1	166	0	22.4

Mean 29.75
Standard Deviation 4.61
Variance 21.28
Standard Score has mean of 50 and standard
deviation of 10

Appendix E

Psychology 151

Two Programs With and Without Feedback

(See Text)

Appendix E

Validity and Reliability

Program and Test

Today in place of a lecture you will be studying the same material on your own, in much the same way as you did with the programed textbook by Geis. You will learn the most if you read each statement carefully and answer the questions fully before moving on to the next statement.

After many of the questions, you will see a box like this:

		X		Both	A	B	Neither

Before reading each statement and question, cover the left side of the box with the 3 x 5 card stapled to the back of your booklet. Then choose an answer and mark the space above your choice. More than one answer may be correct. Then remove the card from the left side to see if your choice is correct. Sometimes the right and wrong answers are explained. For simpler questions and answers, no additional explanation is given.

Before studying this material, you will take a short test to see how much you already know about the topic. Another test will be given at the end to see how much you've learned.

PLEASE DO NOT TURN THE PAGE until you are asked to begin studying the material. You will have plenty of time, so don't rush. But don't stay on one question for a long time.

Reliability and Validity

1. A test is a sample of behavior. It is used to get a maximum amount of pertinent information in a minimum amount of time. It is given under standardized conditions; that is, conditions which are basically the same every time.

   A standardized situation is one criterion of:

   A. A conversation

   B. A test

		X		Both	A	B	Neither

2. You know that in a class, a test is a way of measuring your performance.

   A test is:

   A. An efficient way to study behavior

   B. Used for evaluation

X				Both	A	B	Neither

3. Tests might also be used to:

   A. Predict future behavior

   B. Flunk 151 students

X				Both	A	B	Neither

4. Which of these statements are/is correct?

   A test is:

   A. a sample of behavior

   B. a standardized situation

   C. a predictive instrument

   D. an efficient way to study behavior

4. Continued

			X	A	B	C	All

5. In order to evaluate test performance, psychologists make use of a score. In your college classes your score often is the number of items you got correct. It is used to compare you with others in your class, and it is useful to you in pointing out what parts of the course you are weakest in.

A score is:

A. a numerical representation of test performance.

B. a way of relating the performance of one person to the performance of another

X				Both	A	B	Neither

6. Your test score tells you:

A. your absolute position in the class

B. the true extent of your knowledge

			X	Both	A	B	Neither

7. Your score is useful because:

A. It can be related to other scores

B. It is an absolute and true representation of your knowledge.

	X			Both	A	B	Neither

8. To show the relationship between scores, we use a statistical procedure known as correlation. You have already had some explanation of correlation, so this will be a brief review. A correlation

makes use of two variables. For example, we might want to investigate the relationship between the number of walks along the Red Cedar per week and classroom participation (the number of times you speak in class per week).

What are the two variables or sets of measures in the example?

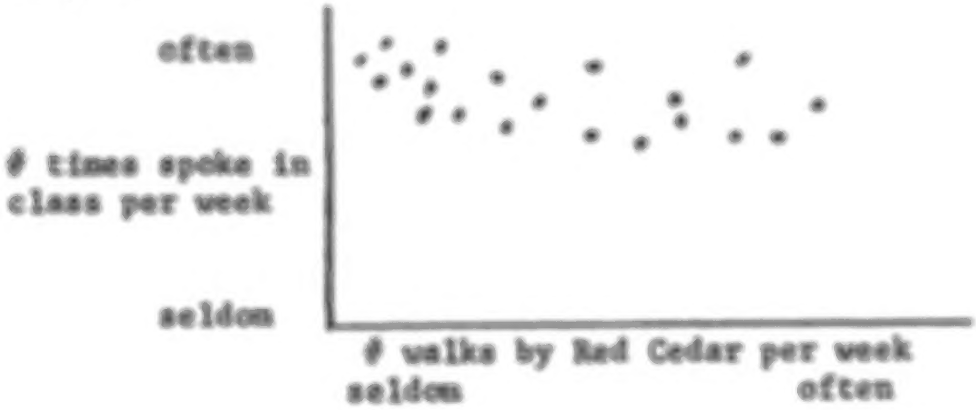
The two variables are the number of walks along the Red Cedar and the number of times you speak in class.

9. Having gotten a measure of the two variables for each person in our study, we might try to put our data in a more concise form. As you may remember, one way to do this is to use a scatter plot. This enables us to "see" a correlation or relationship between the two variables. To "see" a correlation we use a ___________.

---

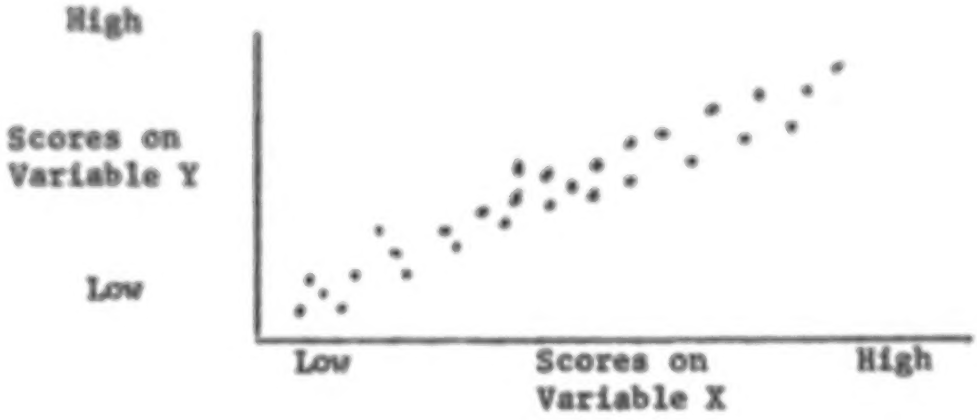
scatter plot

10. We plot one measure on each axis. Then we put a dot representing the correlation of the two variables for each individual in the sample.



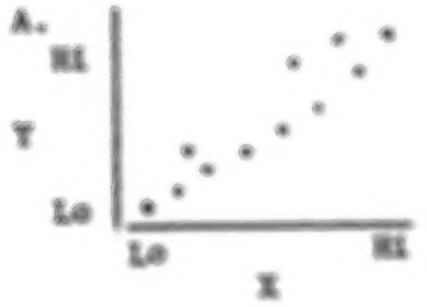
This is the scatter plot for our study.

11. If the correlation between two variables is positive, as the first variable increases, the value of the other variable will also increase. The scatter plot would look something like this.

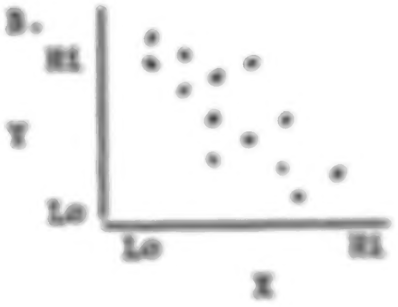


12. If there is a negative correlation between the two variables, as the values of one variable increase, the values of the other variable decrease. Which of the following would be a negative correlation?

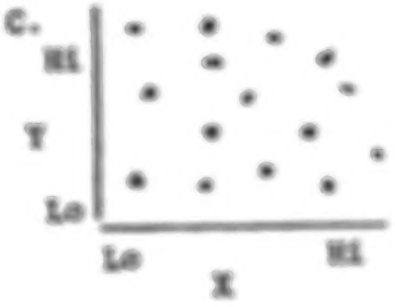
A.



B.



C.



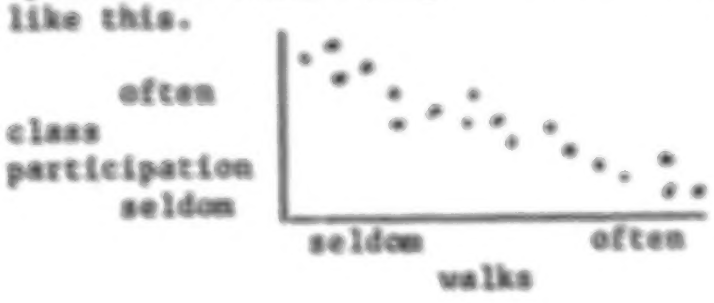
	X		A	B	C

A. This scatter plot shows a positive correlation because those who have low scores on Y also have low scores on X, and those with high scores on Y have high scores on X.

B. This scatter plot shows negative correlation because high scores on one variable go with low scores on the other variable.

C. This scatter plot shows no correlation between X and Y. A person with a low score on X is equally likely to have a low, medium, or high score on Y.

13. In our original example, the correlation between class participation and walks along the Red Cedar, the scatter plot looked like this.



What kind of correlation does it show?

A. positive

B. negative

C. zero

	X		A	B	C

14. It is important to notice that a correlation does not indicate a cause and effect relationship. Your classroom participation and walks along the Red Cedar may correlate highly, but this does not mean that your lack of classroom participation was caused by walking along the Red Cedar, or that not walking along the Red Cedar caused you to participate more in class.

Here's another example. Let us suppose that the number of storks in a particular village one week correlates highly with the number of births in the village that same week. Could we say that the storks caused the births?

	X	Yes	No

I hope you don't need an explanation of that one!

15. A correlation coefficient is:

A. positive, negative, or zero

B. a number which describes the relationship between two variables

C. always a cause and effect relationship

X	X		A	B	C

16. We use a correlation coefficient when we talk about reliability. For example, if you hired a man to work for you, you would expect him to come to work every day and do the same job. If he did so, you might say he was ______________.

reliable

17. Psychologists expect a test to do the same job regularly. If a test consistently measures some performance, it is reliable. To find out how reliable a test is, we use a correlation coefficient.

How many variables do we need?

Two variables

18. To find the reliability coefficient, how many measures from the same individual do we need?

---

two measures

19. For example, we might compare a person's score on one half of a test with the same person's score on the other half of the test. The test halves would be equal in difficulty, format, subject matter, etc. A correlation coefficient may be used as:

A. a measure of relationship between two variables

B. a reliability coefficient

X				Both	A	B	Neither

20. A reliability coefficient may show the relationship between:

A. a walk along the Red Cedar and classroom participation

B. one half of a test and the other half of the same test

		X		Both	A	B	Neither

21. A reliability coefficient could be used to compare performance on one half of a test with performance on the other half of the test.

It could also be used for:

A. comparing performance on a test at one time with later performance on the same test by the same person

B. comparing performance on a test with performance on an alternate form of the same test

X				Both	A	B	Neither

22. Comparing alternate forms of the same test is similar to comparing:

A. an IQ test and a clerical skills test

B. One half of a test with the other half of the same test

		X		Both	A	B	Neither

23. If we compare people's performance on a test with their performance on the same test at a later time, we would expect:

A. high reliability

B. low reliability

C. no reliability

X			A	B	C

24. A reliability coefficient is:

A. a correlation coefficient

B. a correlation between a test and an alternate form of the same test

C. a correlation between halves of a test

D. a correlation between test performance at one time and at a future time

X	X	X	X	A	B	C	D

25. A good test is not only reliable. It is also valid. If a test is valid, it measures what it purports to measure.

This means we would expect to find that a valid intelligence test gives an accurate measure of the intelligence of the person taking the test (the testee).

X		True	False

26. To determine the ____________ of a test, we use a correlation coefficient between the test and external criteria.

A. reliability

B. validity

		X		Both	A	B	Neither

27. Which of the following would be an example of an external criterion which could be used to validate an IQ test?

A. Testee's performance on the even items of the test

B. Testee's school performance

		X		Both	A	B	Neither

A. Comparing performance on even and odd items would check the reliability of the test but not its validity, since both measures are made by the test. To check validity, you need a criterion which is external to the test.

B. School performance is one external criterion which could be used to validate an IQ test, since we assume that both measure intelligence.

28. The external criteria to be used to validate a test must be reliable and representative of the area which the test is measuring.

Which of the following would be reliable and representative measures to use to validate an IQ test?

A. food preferences of the testee

B. hair color of the testee

C. grade point average of the testee

		X		A	B	C	None

29. Which of the following might be used as external criteria for success as a doctor?

A. number of patients

B. number of papers published in journals

C. income

			X	A	B	C	All

30. External criteria serve the same function in relation to future behavior as a test serves in relation to present behavior. External criteria, while not exactly a sample of future behavior, are characteristic of the future behavior and consequently must represent all facets of the behavior and must do so reliably.

A good set of criteria is ________________
and ____________ of the area.

---

reliable, representative

31. Validity is defined as a correlation coefficient between:

A. reliability and external criteria

B. external criteria and internal criteria

C. a test and external criteria

		X	A	B	C

32. How many measures must we have from the same person in order to obtain a validity coefficient?

two

33. Two scores from the same person, a test score and an external criterion score, are used to determine the ____________ of a test.

validity

34. Two scores from the same person, e.g., scores on the same test taken at different times, can be used to determine the _______ of a test.

reliability

35. The following information is from a "success test," success defined here as "making a lot of money."

Subject	Even Items	Odd Items	Income
John	120	100	$15,000
Mary	130	78	10,000
Joe	102	50	5,000
Sue	45	21	1,000

Is the "success test" reliable?

Very probably. There is a positive correlation between scores on the even items and scores on the odd items for each subject.

36. Is the "success test" valid?

Probably, because there is a positive correlation between the test scores and the external criterion of income for each subject.

37. Test A and Test B are two equally difficult forms of a "creativity test."

Subject	Test A	Test B
David	200	100
Jean	100	150
Joyce	73	200
George	63	61

We may conclude that:

A. the test is very reliable

B. the test is not very reliable

C. the test is quite valid

	X		A	B	C

A. If a test is reliable, persons taking the test a second time should obtain a score or ranking similar to the first. Notice in this example how the rank order is changed on Test B.

B. The test is probably not very reliable since there is little correlation between scores on the two forms.

C. Since no scores from an external criterion are given, we have no way of judging the validity of the test.

38. Scores on Test A and Test B appear positively correlated with IQ. Therefore, we can find the IQ scores of six persons and compare these with their scores on Test A and Test B. Our results are as follows:

Group I	Test A	IQ Scores
John	100	150
Joe	70	120
Bill	25	80

Group II	Test B	IQ Scores
David	100	145
Peter	70	123
Stephen	25	79

We may conclude that our tests are __________, but cannot determine their __________.

---

valid, reliability

39. We could not determine whether the test was reliable because:

A. The original test scores are not correlated with the external criterion.

B. We have only one score per subject on the test.

		X		Both	A	B	Neither

A. Correlation of a test score with an external criterion gives a measure of validity, not reliability.

B. From the data given we could not determine whether the tests were reliable, because we did not have two scores from the same or similar tests for each person.

40. If a test measures what it is supposed to measure, it is __________. If it measures the same thing twice, it is __________.

---

valid, reliable

41. In order to determine reliability, (how many) score(s) must be obtained from (how many) person(s).

A. one, one

B. two, two

C. two, one

		X	A	B	C

Test

Reliability and Validity

Select the term that best fits the description on the left. A term may be selected more than once.

1. The consistency with which a test measures whatever it measures.
2. A number indicating degree of relationship between two variables.
3. Comparison of the scores on two halves of the same test.
4. A test measures what it purports to measure.

1. validity
2. response ratio
3. coefficient of correspondence
4. mutuality
5. test
6. reliability
7. correlation coefficient
8. reciprocal
9. standard deviation
10. scatter diagram

---

5. Name of a plot of two correlated variables.
6. One variable increases, the other decreases.
7. A standardized sample of behavior.
8. Two variables decrease or increase together.

1. positive correlation
2. reciprocal
3. median plot
4. respondent
5. relatedness
6. negative correlation
7. test
8. scatter diagram
9. graph
10. reliability

Today in place of a lecture you will be studying the same material on your own, in much the same way as you did with the programed textbook by Geis.

In this particular program there are no answers accompanying the questions. However, you should be able to answer the questions without any trouble. Sometimes in multiple-choice questions, more than one alternative may be correct or none may be correct. You will learn the most if you read each statement carefully and answer the questions fully before moving on to the next statement.

Before studying this material, you will take a short test to see how much you already know about the topic. Another test will be given at the end to see how much you've learned.

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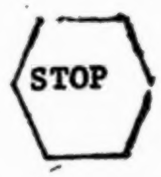
Discrimination

1. A discriminative stimulus is a stimulus which controls some particular response. Here is a stimulus which, hopefully, is a discriminative stimulus for you:

   For what response is this a discriminative stimulus?



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2. When you are driving, you will treat intersections with stop signs differently than intersections without stop signs. It is because of this difference in your behavior that the stop sign is called a discriminative stimulus for stopping.

   Is a stop sign a discriminative stimulus for stopping to a person who does not stop at intersections which have stop signs?

---

3. A stop sign will be a discriminative stimulus for stopping at intersections. It will probably not be a discriminative stimulus for other behaviors. For example, you will not stop breathing when you see a stop sign.

   Are these statements true?

   A. When you speak of discriminative stimuli, you must specify the responses for which that stimulus is discriminative.

   B. A discriminative stimulus for one behavior is always a discriminative stimulus for other behaviors.

---

4. Here are four stimuli which are quite commonly used as discriminative stimuli. Try to list some situations in which these would be discriminative and what responses they would control. Then try to think of some situations (or responses) for which they would not be discriminative.

   The sound of a bell.
   A civil defense siren.
   The words "men" and "women."

---

5. Stimuli which have a discriminative function may either call out (elicit) or prevent (inhibit) responses. A discriminative stimulus which calls out a specified response is abbreviated

S^d ("ess dee").

Which of these sentences makes sense as stated?

A. A "Beware of Dog" sign is an S^d for petting the dog.

B. A stop sign is an S^d for stopping the car.

6. If you were in a building and heard a fire alarm, you would probably leave the building. The fire alarm is an S^d for leaving the building because it ______________.

A. Calls out the response.

B. Calls out leaving-the-building response.

C. Inhibits the stimulus control.

7. A stimulus which inhibits or prevents a specified response is called an

S^{Δ} ("ess delta").

Which of these would be an S^{Δ} for the specified response?

A. A "Beware of Dog" sign (for petting the dog).

B. A stop sign (for going through intersections).

8. Why would a fire alarm be an S^{Δ} for lounging around the building?

9. Fill these in with the appropriate symbols (S^d or S^Δ):

A. An F in ATL is an _______ for jubilation.

B. Thirst is an ______ for drinking.

C. A "Do Not Disturb" sign on a door is an ______ for knocking.

D. A 100 foot cliff is an _______ for jumping.

E. A "No Vacancy" sign is an _________.

F. The doorbell is an _____ for answering the door.

10. Stimulus objects such as signs, signals, and symbols have been deliberately created to function as S^ds and S^Δs. Such stimuli are easily recognized as discriminative stimuli, and the type of stimulus control which they exert is also easily recognized.

Most stimuli which have a discriminative function are not so obviously discriminative. A doorknob does not say "turn me," and a window shade does not say "pull me," yet both are obviously discriminative stimuli.

11. A man walking down the street sees a roller skate on the sidewalk directly in his path. If he steps over the skate or steps around it, then the skate has had some discriminative function over his behavior.

Which statement is true?

A. The skate is an S^d for walking straight ahead.

B. The skate is an S^Δ for walking straight ahead.

C. Even though the skate has some discriminative function, it will not control his behavior in any way.

12. Now if the object lying on the ground had been a gum wrapper instead of a skate, then the man would probably not walk around it or consciously try to step over it.

A large rock or a roller skate
on the sidewalk would be an S^d
for changing walking behavior
but a gum wrapper would not.
True or false?

13. A compulsive tin foil collector and a street cleaner are each approaching a gum wrapper on the sidewalk. What kind of stimulus control will the gum wrapper have if any?

Write your answer, specifying type of stimulus and response.

14. You are cruising down Michigan Avenue approaching a red or green traffic light. If the light is an SΔ for going, then;

A. The light is an S^d for stopping.

B. The light is red.

15. You see some acquaintances approaching your door. You hide in the closet and so not answer the door when you hear them knock.

A. The sight of your friends is an SΔ for hiding and an S^d for answering the door.

B. The sight of your friends is an S^d for hiding and an SΔ for answering the door.

C. The sight of your friends is an S^d for turning you on.

16. Sometimes several discriminative stimuli are presented simultaneously. Cigarette machines and soft drink machines for example usually have several buttons which are discriminative stimuli for pressing. If a soft drink machine sells rootbeer, coke, and orange, and you want coke, which buttons are S^ds and which are S^{Δ}s for pressing?

A. The buttons for rootbeer and orange are S^{Δ}s for pressing.

B. The button for coke is an S^d for pressing.

---

17. When two or more stimuli appear together, this is called simultaneous presentation of stimuli. On coke and cigarette machines the buttons are presented simultaneously.

Are any of the following simultaneous presentations? What is the S^d?

A. You are standing in front of a shelf of vegetables trying to pick out a can of Brand X corn.

B. Your alarm clock rings in the morning.

---

18. Discrimination training is a procedure for training an animal to respond to a particular stimulus.

Which of these could be discrimination training with stimultaneous presentation? Why?

A. Putting a sphere, a cube and a pyramid in front of a monkey and training him to pick up the cube.

B. Training a dog to bark when he hears the word, "speak."

---

19. If a monkey is trained to pick up the cube, he is being trained to use the cube as an S^d for the response of "picking up."

A. The pyramid and the sphere are S^{Δ}s for the picking up response.

B. The cube, the pyramid, and the sphere are all stimuli, but the monkey can only distinguish the cube and the pyramid.

C. Only the cube will have any stimulus properties.

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20. Positive reinforcement is typically used in discrimination training. The trainer selects the stimulus which he wants the animal to learn to use as an S^d and he reinforces responses which the animal makes to the S^d. Responses to the other stimuli are not reinforced.

How would you train the monkey to pick up the cube?

A. Alternately reinforce him for picking up the cube, the pyramid and the sphere.

B. Reinforce him only when he picks up the cube.

C. Say "bad boy" when he picks up the pyramid and the sphere.

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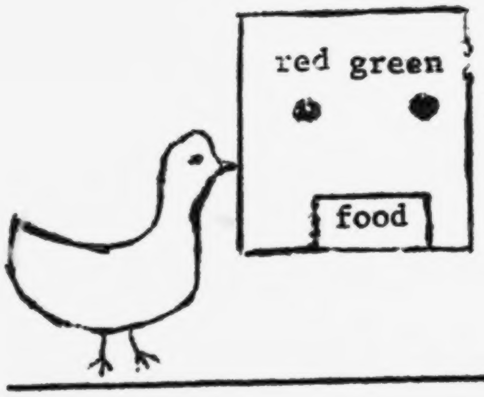
21. There is a red key and a green key above a hole through which food may be delivered to a hungry pigeon. The pigeon will receive a bit of food each time he pecks the red key.



A. This is an instance of discrimination training with alternate reinforcement for the S^d, and the stimuli are presented simultaneously.

B. This is stimultaneous discrimination training with reward for responding to the S^{Δ}.

C. This is simultaneous discrimination training. The pigeon is being trained with positive reinforcement. The red key will become an S^d for pecking.

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22. One way to test whether nonverbal animals can distinguish (perceive a difference) between different stimuli is to use the stimuli in a discrimination training procedure.

A. If the animal can learn a discrimination, then it can be assumed that he can distinguish the differences between them.

B. If the animal cannot learn the discrimination, then he may not be able to distinguish the stimuli.

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23. How could you test whether a cat can distinguish between red and orange? Try to suggest a general procedure.

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24. A lady recently wrote to a pet expert exclaiming that even though she had always heard that dogs cannot see color, she could prove that her dog, Rover, could. Rover doesn't like yellow dog biscuits, and she found that if she held out a yellow and a brown biscuits Rover would always run to the brown one.

The pet expert was perfectly willing to believe that the dog could make the discrimination between the biscuits. He remained dubious about color vision, however. Why?

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25. If you are using discrimination training as a means of discovering whether an animal can distinguish between stimuli on the basis of some dimension (such as color), it is important to control all the other dimensions on which the stimuli may vary.

How can you control the other dimensions?

A. Be careful that the animal has no cues with which to distinguish stimuli other than the one you are testing.

B. The stimuli should consistently differ on only one dimension.

26. A bright young psychology student has manufactured the following piece of apparatus for an experiment in child psychology. The experiment requires that the child can learn to use the green button as an S^d for pressing. He is going to stipulate that all subjects be able to see color in order to participate. A friend says he could use color blind subjects. Another friend says he could use blind subjects. Why?

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27. With a simultaneous presentation of stimuli, it is possible to respond to either the S^d or S^{Δ} at any time. This is similar to the situation encountered when you enter an elevator and press a button for the correct floor. You could press any of the buttons whether they were S^ds or S^{Δ}s for the floor you want.

Discriminating when to get off the elevator is different. As the elevator reaches different floors, some of these floors will be a S^{Δ}s for getting off, and one will be an S^d. You obviously cannot get off the elevator at the right floor and the wrong floor at the same time. In this case, the stimuli are presented successively--one at a time, one after another. This is called a successive presentation of stimuli.

Which of these involves discrimination with successive presentation?

A. Getting off the train at the right town (i. e., responding to the name of the right town).

B. Responding to your name during roll call.

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28. A successive presentation may consist of several stimuli presented one after the other. A single stimulus may also be used in a successive presentation; sometimes it is presented and sometimes it is not. For example, a ringing phone is an S^d for answering. The S^{Δ} consists merely of those periods when the phone is not ringing.

Are these successive presentations? What are the S^ds and S^{Δ}s?

A. An experimenter is flashing red, blue, or green dots on a screen. The subject is to press a button when he sees the red dot.

B. An experimenter is flashing a red dot on a screen. The subject is supposed to press a button when he sees the red dot.

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29. Earlier you learned how a monkey could be taught to pick out a cube from a simultaneous presentation of a cube, a sphere, and a pyramid. If you were going to use a successive presentation to train the monkey how would you present the three stimuli to him?

A. First, place one stimulus in front of him. Then withdraw it and present the second; then withdraw it and present another.

B. Place one stimulus in front of him; then add the second, then add the third.

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30. Up to now, we have been talking as if certain stimuli were always S^ds or S^Δs for certain responses. This obviously is not really true. Not every ringing phone anytime, anywhere, will call out an answering response.

A. Other aspects of the stimulus situation will influence whether a stimulus is used as an S^d.

B. Stimuli invariably call out responses in all situations if they call out the response in one situation.

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31. When a rat is trained to press a bar, the bar becomes an S^d for pressing. Then, when he is trained to press the bar only when a light is on, the light will affect whether he presses the bar. "Light on" is an S^d for responding to the sight of the bar.

Light-off is an _________ for responding to the _________ for pressing.

A. S^d, S^Δ

B. S^Δ, S^Δ

C. S^Δ, S^d

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32. Earlier we mentioned that some people don't stop at stop signs. Actually, this behavior might depend upon whether a policeman is in the vicinity. The policeman calls out the behavior of responding to the stop sign.

A policeman is an ______________ for responding to the ______________ for stopping.

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33. Given the following stimuli, response, etc., construct sentences or diagrams making use of the symbols you have learned which describe possible stimulus situations and responses. What will be presented simultaneously and/or successively?

TIME: Occasions when you are thirsty.

PLACE: You are standing in front of a soft drink machine.

OTHER FEATURES: The occasional presence of an "out of order" sign.

RESPONSE UNDER CONSIDERATION: Putting a dime in the soft drink machine.

Test

Discrimination

Select the term that best fits the description on the left. A term may be selected more than once.

1. Teaching a dog to bark at prowlers but not to bite the mailman.
2. To facilitate discrimination learning, the subject could be given __________ for not responding in the presence of the S.
3. The differential reinforcement of a response in the presence of one stimulus and not in the presence of another stimulus.
4. To facilitate discrimination learning, the subject could be given ______________ for responding in the presence of the S.

1. positive reinforcement
2. punishment training
3. discriminative stimuli
4. negative reinforcement
5. internal stimuli
6. discrimination training
7. unconditional stimuli
8. S^d
9. successive stimuli
10. simultaneous stimuli

- -

5. A stimulus which inhibits a response.
6. A traffic light is an example of presentation of stimuli.
7. S^ds are stimuli which __________ responses.
8. Stimuli which control some particular response.

1. discriminative stimuli
2. reinforce
3. simultaneous
4. elicit
5. S^{Δ}
6. unconditional stimuli
7. successive
8. inhibit
9. S^d
10. internal stimuli

Appendix F

Comparison of Individual Difference Means and Standard Deviations of Subjects in the Two Experiments

Appendix F

Comparison of individual difference means and standard deviations of subjects in the two experiments

	Mathematics 082		Psychology 151	
Variable	Mean	S.D.	Mean	S.D.
Sex	1.310	0.464	1.522	0.502
Inform	46.743	7.464	47.252	9.002
Math	10.479	2.382	19.694	4.586
Arith-op	16.017	3.408	16.573	3.247
Teachcon	12.673	3.006	12.406	2.882
Midterm B	41.074	3.680	*	*
Final tot	43.477	9.043	*	*
English	22.423	5.395	25.080	5.684
Numer	25.421	5.103	32.252	9.073
Search tk	70.434	13.961	73.415	14.251
Eas-lng	15.133	3.228	16.125	3.793
Pho-phil	58.513	16.317	63.278	15.435
Mid total	80.074	6.515	*	*
Dept Finl	23.107	14.431	*	*
Reading	29.175	5.852	30.640	6.496
Arith	32.883	3.126	32.192	4.039
Svib-mf	48.035	10.775	*	*
Indepilng	11.630	3.100	11.479	2.734
Units	37.790	6.310	*	*
Final A	29.483	4.722	*	*